HARVARD COLLEGE
JAN 10 1890
LIBRARY.

THE TELEGRAPHIC JOURNAL AND
ELECTRICAL REVIEW.

VOL. XXV. DECEMBER 27, 1889. NO. 631.

CONTENTS:

	PAGE
The Lighting of Railway Trains	709
Electrical Companies	710
Electric Lighting at Nostell Priory (*illustrated*)	713
Alternating *v.* Low-Tension Continuous Currents	714
Tests of the Timmis and Forbes Patent Electro-Magnetic Railway Brake (*illustrated*)	715
Form and Efficiency of Incandescent Filaments (*concluded*)	716
A Meteorological Phenomenon	717
The Protection of Telegraph and Telephone Lines Against Electric Light Wires	717
Sir Wm. Thomson's New Inspectional Electric Instruments (*illustrated*)	718
French Submarine Boat	719
Subways	719
Notes...	720
City Notes, &c. :—Metropolitan Electric Supply Company ...	723
Traffic Receipts	724
On the Heating of Conductors by Electric Currents.—III. ...	725
Tests made for Health Department of the City of New York	729
Some New Forms of Electrical Treatment	730
New Patents...	731
Abstracts of Published Specifications	731
Correspondence :—	
Edison and the Lalande Battery	731
Ozone	732
Munro and Jamieson's Pocket-book	732

THE LIGHTING OF RAILWAY TRAINS.

THE success attending the trials of the electric light, to which we referred in a previous article, would appear to fairly dispose of any question of doubt as to its practical application for this purpose. It is understood that these trials were undertaken, in the first instance, with the object of ascertaining whether this form of light could be applied in such a manner as to meet, to the utmost, the exigencies of railway working. To this intent the trains were to be capable of being broken up, or made up, at any point of the journey; portions were to be sent certain distances dependent entirely upon the current stored up within the vehicles so despatched; carriages were to be "slipped" on the way, and the whole train was to be capable of being turned about in any direction. In fact, the officials were to deal with it precisely as they would with any other train not so fitted with electrical apparatus, except that the stock was to be kept together, so far as it could be, in order that the electrical continuity throughout the train might not be disturbed—not that this has always been secured. On the best regulated lines mishaps will arise, and so, with these experiments, cases have occurred more than once when this continuity has, by the interposition of an unfitted vehicle, been broken. Yet the lighting has gone on. Of course, the vehicles thus separated from the dynamo have missed their charge on the journey; but it does not appear to have done much harm, for, with prompt regularity, the trains may have been noticed arriving and leaving St. Pancras at their appointed times.

Now, when we come to consider that here we have two trains specially fitted, required to run long trips—London, Manchester, and Liverpool—to and from, daily, without spare vans or dynamos, subject to really unavoidable interference occasionally, and yet continuing to respond satisfactorily to that demanded of it, we are forced to the conclusion that the obstacles which stood forth when its application to general railway requirements were first considered, and which we may assume have for so long deterred others from boldly facing them, have been overcome, and that electricity has found in railway train lighting a field of utility of no mean extent. The practicability of its application is established.

Happy in the success achieved, it, however, behoves us to pursue our way with unwonted wariness. We have little fear of the verdict of the public in their choice of the form of light which would be most agreeable to their taste; still, the voice of the public, recognised as it often is, is not always strong enough to control the purse-strings. In compressed oil gas the electric light will find a powerful opponent. In gas we have an old-established friend which needs no experiments to prove its adaptability. It has been in use on our Metropolitan, and to some extent on other lines, the Midland included, for some time. As an illuminant opposed to the old oil lamps it has gained praise, and been received by many with satisfaction. Doubtless, with strict attention to the pressure and a somewhat more liberal supply of burners, it may be made as good a reading light as can be required. But when this has been done and the highest brilliancy required has been attained, have we achieved all that is desired? Would gas, even then, hold the field against the electric light? We believe it will not. We believe the electric light is destined to be the light of the future in this as in many other ways. We are by no means bigoted in this assumption. Our reasons are obvious.

Railway companies will naturally not be oblivious to the views of their patrons, still they will consider the question of cost, and that very carefully. Gas, as we say, has passed its experimental stage. What it will do; what it will cost is before us. Electricity is, in this case certainly, in its infancy. What it can do we know, but what it will cost is not so clear—with electricity everything is new. Its cost, whatever it is, is at its maximum; with it, not as with gas, progress means reduced cost. Each extension of its application will show us some way of reducing charges—some way of simplification. With trains fitted with the electric light, which are not required to be broken up on the journey or at its end, the cost of fitting and working must evidently be very moderate; but where, as in main line trains, each carriage has to carry its own batteries, the cost will doubtless be materially increased, and here it is that a comparison between the cost of fitting railway stock with the electric light will vie with that for gas. Should the cost be the same, or thereabout, then the advantage is certainly in favour of electricity for the reasons already announced; viz., that in the one case we are dealing with that which has been worked out to its lowest depths, whereas with the new illuminant we have everything new—new applications, new designs and models. Arrived at a beaten track, applied in large quantities, railway companies will, we have no hesitation in saying, find the cost quite cope with that of gas. This, as regards main line trains: with trains not to be broken up, the cost must be materially less.

In considering the application of compressed gas there are many points to which it is desirable attention should be directed, and that in no doubtful sense. The real cost of anything of this nature is, after all, not so much in the first outlay as in its working. Manufacturers will inform us that compressed gas can be produced at ·15 of a penny per light per hour. We hardly think this is the case wth the lights on the Metropolitan; but whether such is so or not, is this the actual cost for the light produced in the carriage? We know such is not the case. The real cost of gas-lighted trains is to be found in the attendant expenses—expenses which do not appear, and which have been practically disregarded. Let us run our eye over any large railway system, and for a moment study its method of working. How many gas manufacturing depôts will it require to feed all its trains with gas? Can those depôts be established at the stations at which the trains are made up, or must the coaches be conveyed to the depôts for the purpose? In either case, a considerable cost must be incurred. Are such charges taken into consideration? We have never seen them included in any statement of cost. We have heard it said that compressed gas may be manufactured at any reasonable distance, and carried to the chief stations for supplying the coaches. We question whether the traffic of a busy station would admit of trains standing for this purpose. To take as an example the Metropolitan is scarcely a fair comparison, for the reason that its trains travelling in a circle are in their ordinary course able to pause at the charging station at stated times. Its area is circumscribed, whilst its consumption is practically continuous—all telling in favour of a cheap production. Gas or electricity to prove economical must be applied to the entire stock. To employ either partially means the retention of the existing staff of lamp attendants, lamp rooms, &c. In such circumstances confusion rather than economy would be the result.

It is not for us to prejudge the matter either way, nor to urge railway companies to embark hastily in the adoption of that, the very novelty of the application of which should induce us to proceed with care and certainty as we go. At the same time, it would be a sheer waste of money to incur the expense of the adoption of gas when there appears so little doubt of the more acceptable form of light being entirely at their disposal practically forthwith.

ELECTRICAL COMPANIES.

COMPANIES are of ancient origin. Adam and Eve were a limited company—a very limited company—which soon got into trouble, as has been a way with companies from their earliest history. Nature has formed some men to form companies, and some to be shareholders in companies, which is considerate, and good for the former. Directors she seems to have frequently left to chance.

Companies have their use, or they would not exist. They also have their abuse; much, sometimes. In the present day they are necessary evils. Money is more diffused than it was, and co-operation in some form is a necessity. Although the time may be coming when, as Disraeli predicted, there will be only the very rich and the very poor, at present there is still a middle class with moderate sums to invest, and they form the bulk of holders in most undertakings. The large blocks of shares are, of course, held by the wealthy, and a fair sprinkling of titles is to be found on all lists of established companies.

The Companies' Acts have met a decided want. Formerly, many a family was ruined through the head possessing shares on which he had to pay call upon call, because some of his co-shareholders were impecunious, and others judiciously disappeared. If a man now invests more deeply than he can afford in any one concern, he must take the consequences; but if he uses common discretion, although he may lose money, he is protected from destruction. Barristers, solicitors, auditors reap rich harvests of fees, the guinea-pig flourishes and waxes fat, and a company requires more clerks than a private firm. These live on the profits of the company, if it make any, to the good of the community, which accounts partially for the fact that sound businesses turned into limited companies often make poorer net returns thereafter.

But there are many valid reasons why they should be so converted. A one-man business may be the best managed, because the strings are all in one hand; but should that hand fail, it is liable to fall like a house of cards. Therefore, a prudent father forms his business into a joint stock one, in order that when he is gone his family may retain a substantial interest in it. Or perhaps extra capital can be employed with remunerative effect, and so the public be admitted to their advantage, without loss of income to the proprietor. Again, a new and large enterprise has to be started. The initiator has not the capital, and it would be impossible to find one rich man to risk the venture. Here the limited company is a distinct benefit to commerce. The other side of the picture is when rotten businesses appeal to the public for a new lease of life, and immature or unprofitable projects are brought before it. The remedy in these cases is with the public itself: it can let them alone. *Caveat emptor* is a necessary rule, and there are those whom no legislation can protect.

Undoubtedly the private firm has the best chance, especially in technical businesses. In it there is but one interest. If the head suffers all the members suffer with it. In companies the interests are various, and often conflicting. There is the company's interest, which is looked after so long as it jumps with the personal. It is useless to say this should not be so, and no safeguards can entirely prevent it. Other than clever men are no use, and clever men are usually ambitious. They have constantly before their eyes the day when they will start for themselves, and look upon their situation as a place wherein to gain experience and connection. They strive their hardest for power, because power means pay. They have a great objection to a good second, and not unfrequently attempt to make their position more secure by getting rid of such an one. A board is not composed of directors who all know the details of the affair which they control. Sometimes none of them do. It falls into the hands of an executive officer whom they trust sometimes too little and sometimes too much. If the former, he is hampered; if the latter, he presses for more salary. Boards make work in a variety of ways; their ingenuity is sometimes astonishing, and that work has to be paid for. The registration of shares, printing of circulars, postages, and kindred expenses are inseparable from company management. The solicitor and expert have to be called in more frequently than in firms, and there is the professional audit. All these expenses tell up, and, appreciably felt in large concerns, press heavily on small. The limiting of small affairs should be deprecated. It offers a temptation to the manager to obtain credit recklessly, and can rarely result in permanent good to anybody.

On the other hand, large undertakings, especially connected with a new industry such as electric lighting and power, some of which, from necessity, must be commenced on a sufficiently large scale, could hardly be inaugurated privately. For such schemes capital must be drawn from an extended field, and the wider the area the better.

In eschewing the evil and choosing the good, depends, as we have before pointed out, the credit of the industry and the hope of investors.

In another portion of our journal will be found a description of an earthenware pipe or conduit for underground mains, which promises to be successful in many cases, especially through ground not likely to be disturbed by traffic, &c. (one of the great causes of failure where earthenware pipes have been used), as the addition of extra cables will not be a matter of great difficulty. This is the earthenware pipe designed for the Nostell Priory installation, and manufactured and laid down in the summer of 1887. There is, however, one strange point about this particular system of piping, and that is, that a precisely similar plan has been recently but independently suggested.

In a paper read before the Electrical Engineers last session by Mr. Verity on "Underground conduits and electrical conductors," a system almost identically similar is described there under the name of the "Doulton conduit," but no mention is made, however, of such a conduit having ever been in practical use. The conduit we have mentioned in our article was, as we have personal knowledge of, laid down in 1887. So to all appearance this latter one would seem to have priority.

The following facts, however, would seem to give some further information on the subject. On June 1st, 1888, we published an article by Mr. Chas. W. Farquhar (to which our attention has now been directed) giving a brief description with illustrations of a system being introduced (under a patent) by the firm of Doulton and Co., Lambeth, London. This description agrees almost exactly with the one we have mentioned, which was actually underground about 12 months previously. This is another instance of how similar ideas and productions emanate from two different people working unknown to each other. In this case, however, there cannot be much doubt about the priority of claim.

The number of deaths which have taken place during the last few months in New York through persons coming into contact with electric light conductors has caused the Board of Electrical Control there to issue very stringent regulations regarding these wires, the most important being that they shall all be placed underground. The result of this has been that many miles of conductors have been ruthlessly cut down by the order of the Mayor of that city, and there are yet thousands of miles of overhead electric light wires to be removed and new cables to be placed underground in their stead. The public sentiment against overhead conductors has, in consequence of the many casualties, become so strong, that no other course seemed open for the Board of Control to adopt, and now many of the streets in which electric lighting was formerly employed are at present either in darkness at night, or are lighted as previously by gas. In England, owing to the liberal policy of the Board of Trade, no similar drastic measures have been taken, and the "model order" of Major Marindin, which stipulates that in future all electric light conductors shall be placed underground, and that those already carried overhead shall within two years from the issue of the regulation be laid underground has, with the exception of one or two minor points, met with general approval. The fact that this policy has been followed in this country, and that almost similar steps have been taken in New York, has caused the governments of other countries to consider the subject. The German Government is now taking action in the matter, and has just decided to put underground all the telephone, telegraph and, we also believe, the electric light wires. In Paris most of the electric light cables are laid underground, but in the French provincial towns they are generally run overhead. This state of affairs prevails also in Spain and, to a certain extent, in Austria-Hungary. The most recent to take action in this direction is the Italian Government, which has just adopted a policy by which the telegraph and telephone wires, the latter of which the Government proposes to acquire, will be protected from the influence exerted upon them both by the induction from and contact with electric light and power cables. The regulations may be seen in our other pages.

IN underground wiring, the most essential point is to commence by laying down the best of cable, for unless the cable is good as to insulation, well protected mechanically, and of sufficient section to resist longitudinal expansion during the process of drawing it into the conduits, the subsequent working of the electric circuit on which it is employed must always be unsatisfactory. American experience has shown that a cable, having a core of No. 10 copper, was so injured whilst being laid that it was quite useless during damp weather, and gave rise to much trouble. On replacing it with another, with a core of No. 8 copper wire, the difficulty was overcome, and it was found no longer compulsory to use a watertight conduit. If wood is employed in the construction, the chief care to be observed is to avoid preserving the timber with creosote, or any substance exerting a destructive effect on the lead covering. After drawing the cable through a duct the ends should never be left open, otherwise dampness invariably creeps up the core and damages the insulation. With the above precautions being observed, there has been little trouble in keeping a line in working order at Springfield, Mass., for more than three years.

THE application of Mr. Leeson for an injunction to restrain the General Medical Council from removing his name from the register of medical practitioners has failed, although Mr. Justice Fry, for reasons best known to himself, disagreed with his brother judges. However, this gentleman's interpretation of a diaphragm in a famous telephonic lawsuit was sufficiently removed from the views held by less intellectual people to stamp him as the possessor of very original powers of reasoning. We trust that this action on the part of the General Medical Council is but the beginning of the end, and probably Mr. Leeson has now every reason to regret that he became the Associate of the President of the British Association of Medical Electricians.

Modern Light and Heat appears to have started a Westinghouse baiting match, and in the course of its criticisms does not spare Mr. Westinghouse personally nor the manner in which his companies have been financed and managed.

EDISON has gained another victory in a patent case; this time in Canada. It will be remembered that the Deputy-Commissioner of Patents decided last February adversely to the Edison incandescent lamp patent, and under sec. 37, chap. 61, Revised Statutes of Canada, it was declared null and void. Some doubt arose as to the jurisdiction of the Deputy-Commissioner, and it was decided to retry the case. The case was accordingly reheard before the Minister of Agriculture; the Minister of Justice sat with the Minister of Agriculture at the hearing. At the new trial the former evidence was accepted by both parties, and some further evidence was taken. Besides the argument at the first hearing, a written statement was put in, with consent, by the respondents, to which the petitioners furnished a reply. The Minister found for the validity of the patent for the following reasons:—(1) That the patentee did, within two years from the date of the patent in dispute, commence to construct lamps under the invention comprised in the patent, and thereafter continuously carry on the manufacture of such lamps in Canada. (2) That after the expiration of 12 months from the granting of said patent neither the patentee nor his agents did import the invention for which the patent was granted.

JUDGING from the report drawn up by the Minister of Justice, we should say that Edison is fairly entitled to his verdict. The points on which the petitioners relied to invalidate the patent are somewhat trivial: (1) That an extension of time for commencing the manufacture of lamps in Canada was obtained in 1881 by fraud. This application was an *ex parte* statement necessarily, and although possibly exaggerated, there was no evidence of fraud. (2) That completed lamps were imported. Four lamps were imported which could only be looked upon as samples showing what the complete invention had to be, and some lamps said to have been imported for the Latrine Canal, turned out to be lamp fittings, not lamps. (3) That the lamps made in Canada were constructed with parts manufactured abroad, and imported from the Edison factories in the United States. These parts consisted of glass bulbs, platinum wire, copper wire, baked filaments, and connection pieces. None of these parts, as imported, being claimed in the patent, and as each part may be used by any person for divers purposes; and as all the essential portions of the lamp, viz., that which is covered by the patent, is done in Canada, there can be no reason sufficiently strong to upset the patent rights in the mere fact that some parts used in the complete manufacture were imported. (4) That lamps could not be had to purchase at a reasonable price. All under this head that can be alleged against the respondents is, that in the early days, they would not sell their lamps to people not provided with the Edison dynamo and plant, as it had been proved on several occasions when the Edison lamp was run by plants of other makers, to be detrimental to the Edison interests. The restriction as to sales was eventually withdrawn. The contention by the petitioners that the manufactory erected in Canada, and the lamps made therein—which latter could not be purchased—were only means of "fooling the Canadians," could not be supported, as the factory had turned out, up to the end of last year, some 66,500 completed lamps.

"IT is seldom that this journal refers to its merits or institutes comparisons between its achievements and those of its contemporaries. But the last number of the *Western Electrician* so strikingly illustrates its superiority, that we may be pardoned if we call attention to the fact." This is the modest manner in which the electrical journal hailing from the "hub of the universe" commences a leaderette which, of course, naturally ends in the complete discomfiture of its New York rivals at which it is aimed. We await with much interest the *quid pro quo*.

As underground conductors make way in London we may occasionally expect something like this in our dailies, unless precautions, in the nature of those which we have already indicated, are provided. A New York paper of recent date says: "A manhole plate of ordinary size covers a manhole in the bend of Minetta Street. Yesterday that plate sailed skyward for a dozen feet, followed by a volume of flame beautiful to behold, and attended by a crash of glass from near-by windows and a reverberating report."

THE New York *Electrical Engineer* seems to be at loggerheads with quite a number of its contemporaries. *Modern Light and Heat* states that this explosive magazine is familiarly known amongst the electrical fraternity as the Westinghouse transformer.

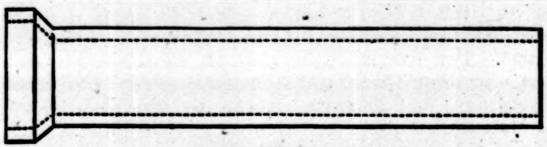
ELECTRIC LIGHTING AT NOSTELL PRIORY.

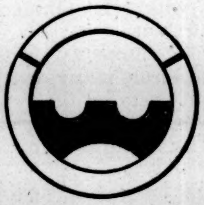
AN electric light installation of an important character, and possessing some features of exceptional interest, was carried out rather more than two years ago at Nostell Priory, near Wakefield, the well-known seat of Lord St. Oswald. A description was not given of this at the time, as it was considered desirable that certain portions of the work should have stood the test of time before being brought to the notice of our readers.

When it was arranged that the Priory—a very large mansion, built during the last century—should be electrically lighted in preference to having gas brought in, it was decided that the power for doing so should be fixed at the collieries owned by Lord St. Oswald at Nostell, close to the Great Northern Railway, distant nearly half a mile from the house. The sale of the plant and cables at the Exhibition at South Kensington was an opportunity which was utilised, and the large engine built by Messrs. Goodfellow and Matthews, of Hyde, and a quantity of heavy cables were purchased for the purposes of the installation. The engine was forwarded to Nostell, and, after being put in proper order, was fixed in position in the mechanics' shop at the colliery works. The cables were examined after their delivery at the same place, and, being found to require a large amount of repairing and jointing, were forwarded to the works of Messrs. Walter T. Glover & Co., at Salford, Manchester. The cables, all of 19-strand heavy wires, amounting to a considerable number of various lengths, were found after examination to be of different makes and insulation; some of vulcanised rubber, some of pure rubber, and some of gutta percha insulation. It was found that, by the addition of some new cable, one main could be formed of wire insulated with pure rubber, whilst the other could be formed of vulcanised rubber, the gutta percha portions being left for house mains. After a considerable amount of trouble, cutting out some bad joints (some unsoldered) and repairing numerous open places (where the exhibition mains had been tapped), the several cables were jointed up into four special lengths, coiled on drums and forwarded to Nostell. These lengths were specially arranged, in order to facilitate the operation of laying the cables underground. It may be remarked that the repaired cables, which had been put in thorough good order and excellently finished, tested very well before leaving the works, and also after being laid, and indeed up to the present time.

The route from the Priory to the colliery was through the park, by which the house is surrounded, to the main road, a distance of about 250 yards, thence through a plantation and some fields, to the colliery, a distance of about 500 yards. The cables were so arranged that the only joints necessary should be made on the colliery side of the main road, where a special man-hole had been built, as the cables came in at different levels. Under the main road iron pipes, well jointed, had been laid, through which the cables were drawn; for the rest of the distance earthenware pipes of an entirely novel construction were used. These pipes facilitated the work of laying in the cables, and as time has shown, have answered very successfully the favourable expectations formed of them.

The accompanying illustration will easily explain their special construction and novelty. These pipes are 6-inch earthenware sanitary pipes, with about one-third of the circumference *nearly* cut through before baking. When brought out for use, this portion of the pipe will, on being tapped along the nicks with a hammer, come loose, and can be lifted off. The pipes being laid in the trough prepared for them, and properly jointed, it will be seen that throughout their length they will have the upper third of their circumference open, enabling cables to be easily deposited inside, without either damage to the pipes or the cables. In addition to this special arrangement, there was also provided in the pipes, at short intervals, an earthenware bridge of the form shown in the enlarged section, containing two grooves for the cables to rest in and be kept separate, and having the under portion cut away, so that any water which might get into the pipes would have a free passage to the nearest drain place. The trench in which these pipes were laid was cut sufficiently deep to allow of a bed of rough clinker and brick, and up to the level of the top of the pipe to allow of drainage. From the house to the roadway there was a fall, but at the roadway the cables to the colliery were in consequence partly of the depth of the pipes under the road, and of the height of the bank on that side considerably higher than the others. It was necessary here to get down to the level of the pipes under the road, and a manhole of considerable dimensions, well drained and bricked all round to a depth of 8 feet, was constructed; at the lower level the cables from under the road came in, and at the upper level the cables from the colliery; this manhole was well protected with a stone cover, and then a large amount of earth put over. In here the several cables were permanently jointed, and after the lapse of more than two years we can safely assert that the cables in this manhole are in excellent condition, and the place itself all that could be desired.





The drum carrying one cable was mounted on tressels which had been fixed on a low cart, and as the cart was drawn forward the cable was payed out and placed carefully in its proper groove in the earthenware pipe; each cable was worked in the same way, and the time occupied was very short indeed; it will be understood that the two cables from the house had to have their ends drawn through the pipes under the road. When the operation of laying the cables had been completed, and each cable properly placed in its own groove, the lid, or loose portion of the circumference of the pipe, was put in its proper place after some clay had been put on the pipe edges; when pressed home the joint was complete. The trenches were filled in, and have remained undisturbed ever since, except at one point for examination lately, when everything was found satisfactory, the lids being water-tight.

We may add that some wires for the purpose of signalling and telephoning were placed in the pipes, and in the section between the house and the roadway an extra pair of cables was put in, with the view of a further extension of the installation. This was done in order not to have to disturb the ground near the mansion a second time. As regards these earthenware pipes, it may be mentioned that as it was only intended originally to place two cables in them, only two grooves were made in the bridges. This system of piping for underground cables was devised early in 1887 by the Hon. G. W. Winn, one of Lord St. Oswald's sons, and the pipes were manufactured for him at Pontefract.

The total number of incandescent lamps in the house are equal to 350 16-C.P. lamps; but they comprise three 300 C.P. Sunbeam lamps, some 32 C.P., a large number of 16 C.P., and some 8 C.P., which are used principally in the cellars and at various points. The "Sunbeam" lamps are used very effectively, fixed below the roof, lighting up the staircases and landings; other lamps have been fixed in existing fittings, which have been specially altered and wired. Some of the rooms on the ground-floor are most efficiently and surprisingly lighted by placing the lamps round the rooms, behind the cornices, and completely out of sight. The light is thrown on to the curved ceilings and reflected evenly over the rooms, which appear bathed in a soft and pleasant light without shadow, and as the various sources of the light are invisible the effect is very charming. This method of lighting, though somewhat wasteful of power, is exceedingly successful and pleasing, and it has met with general approbation. Every precaution has been taken throughout the house with regard to the safety fuses, and switches are conveniently placed commanding various sections of lighting. Separate switches being also fixed to the individual lamps. The whole arrangements have worked up to the present in a most satisfactory manner, the more creditable as the principal share of the work was carried out by the Hon. G. W. Winn, who has not been brought up to the profession of an electrical engineer.

The engineering shop at the colliery, which has been fitted up with the necessary power for lighting the Priory, contains some special features, for not only is the ordinary lighting of the house attended to, but there is a day service laid on, and a night and day service for the colliery below and the shops above; also an arc lamp service for the coal-yards and railway sidings. For the main service of the mansion there is an excellent Crompton dynamo, with an output of 220 ampères at 125 volts, driven by the Goodfellow and Matthew's engine to which we have alluded. This engine is arranged with six cylinders, *i.e.*, with one high and one low pressure cylinder, working on each of three separate rods connected on to one crank, and arranged so that the circle is divided into three equal parts. The steam only acts on the outside areas of the pistons, thus rendering it possible to run those engines at a high speed. The steam is admitted to the respective pistons by separate sets of piston valves, fitted with a patent relief motion for letting out any water which may accumulate from time to time in the cylinders, and which would otherwise cause damage to the engine.

In addition to the main dynamo for the Priory installation, there are three small Crompton dynamos—one (90 ampères at 100 volts) for the colliery lighting, and one (15 ampères at 200 volts) for the arc lamps in the pit yard, and one dynamo (30 ampères at 100 volts) spare. At the colliery there are over 100 incandescent lamps, of which a considerable number are below ground. In this shop is fixed a switchboard with the necessary ammeters and voltmeters, and the dynamos and circuits are so arranged that every combination is possible, so that the dynamos can be connected to all or any circuit. For the purpose of lighting, &c., a high speed three cylinder vertical engine works a countershaft, to which the several dynamos can be connected by a Mather and Platt clutch. This engine has been running night and day for a continuous run of many months without a breakdown. It was constructed at the colliery shops by the Hon. G. W. Winn, who is a mechanic of the highest order.

During the daytime a current of low power is kept on the house mains, in order that light may be obtained in the cellars or other dark places; and at a very short notice the whole power can be laid on. In this respect, as regards the application and distribution of power, the arrangements are simple and excellent. The dynamos and general fittings were supplied by Messrs. Crompton & Co., who also lent the services of some men to carry out the necessary wiring, connections, &c.; the cables of the various sizes required were, as we stated, repaired and supplied by Messrs. W. T. Glover and Co., but the entire electrical arrangements, from the early conception to the final completion, have been designed and carried out under the skilful hand of the Hon. G. W. Winn, whose knowledge of electrical matters and surprising mechanical skill have made this installation especially successful and remarkable in many of the details.

ALTERNATING v. LOW-TENSION CONTINUOUS CURRENTS.

"It seems probable that the time is not far distant when the regulations governing the distribution of electricity will rigidly prohibit direct electrical connection between the street wires and the local service wires inside houses, thereby excluding from dwelling places all the dangerous effects possible to ensue from accidental leakages in the underground system." This is the conclusion arrived at by Mr. George Westinghouse, jun., in a reply he has published to Mr. Edison's article in the *North American Review*, entitled, "The Dangers of Electric Lighting." The wording of the above paragraph sounds like a variation on Harold P. Brown, and is not wholly free from the suspicion that the subject has been viewed solely from the standpoint of self-interest.

No commercial controversy has been carried on with so much bitterness as the struggle between the various electric light and power interests; and the efforts of the great corporations to thwart one another, and to hinder their mutual progress, have been the means of squandering an immense amount of energy and money throughout the States.

According to Mr. Westinghouse, the Edison system of distribution was founded on the existing method of gas distribution, in which the conductors are laid under the streets, with branches or connections to every house, supplied by generators placed in central stations. The pressure in an electric main constructed on this principle must necessarily be kept low, from the fact of the commercial impossibility of making an incandescent lamp of any desired high resistance. The formidable amount of copper required for a conductor carrying a sufficient current at low potential, has led to the adoption of the three-wire system (said to be an improvement on earlier patents of Sawyer and Brush). The electrical distribution by a network of wires is, however, different to that of a gas pipe system in regard to leakage. A gas leak is local, and produces no effect at a distance. A leak of electric current has a tendency to concentrate and form a short circuit, the result on surrounding substances being disastrous. When a gas pipe is fractured at one spot, much loss of gas will take place; but it does not necessarily follow that the consumers should lose their supply. With the low pressure electric supply, a big leak or short circuit may extinguish every light on the entire system; repairs on a network also take more time to complete, owing to the difficulty of locating the fault.

The supporters of the alternating current take exception to the experiments conducted by Mr. A. E. Kennelly at the Edison laboratory, because the so-called alternating current used for these experiments was not the alternating current of commerce, but was an Edison direct continuous current, made alternating by a "pole changer," which is supposed to produce a far more dangerous current than the true alternating one from a Westinghouse machine, on account of the high tension resulting from a partial discharge of the field magnets. At any rate, there can be no dispute as to the current used by Mr. Kennelly being an alternating one, which was all that was required for his work; the same can scarcely be claimed for an experiment made by Mr. Westinghouse to prove the dire effects of less than 100 volts continuous current on the human body. "Let anyone connect a tin pan to one of the electric wires, and place therein a thick piece of beef, and upon this a gridiron of metal connected to the other wire. The electrical energy exhibited in the steaming and cooking of this beef may possibly surprise the experimenter. If the current is from an underground main, the experiment may be varied by connecting the gridiron to a water pipe with like results. With even less than 100 volts, it is painful beyond endurance to press firmly with the hands the brushes or any bright brass work of the dynamo, or to grasp any metal connected with the wires." From this it would appear that advocating alternating currents creates a tender skin, but, from our own experience with well made English machines of 100 volts potential, no such result has occurred in the least approaching to pain beyond endurance. For the tin pan and gridiron experiment, many live specimens of the Mullingar breed of cattle could be found willing to undergo the process—for a consideration; but in that case we doubt the quoted results; the conditions would be different. In preparing the thick piece of beef, Mr. Preece's celebrated experience with the pig had not been forgotten.

There is a considerable amount of truth in the statement that the insulation required for a cable to carry a 1,000-volt alternating current in underground circuits affords greater security against leakage than the present somewhat slipshod method adopted by the Edison companies.

The two parties agree on one point, viz., that no greater potential than 100 volts should be allowed to enter a private dwelling. The transformer people say that their system is safer than Edison's, for the reason that the main current never enters the house. They cannot deny that under possible circumstances that event might occur, and with fatal results as is evidenced by the fatality at Toledo, Ohio, on the 17th inst.; this could not happen with Edison plant. The fire risk is common to both systems. The advantage offered by the alternating system, in supplying its customers over large areas and at a reasonable price, has made it popular, and on that account it is largely cutting out the continuous current for incandescent public lighting.

TESTS OF THE TIMMIS AND FORBES PATENT ELECTRO-MAGNETIC RAILWAY BRAKE.

THIS brake, which we illustrate below, depends for its action upon the attractive force set up between the poles of an electromagnet and its armature when a current flows round the former. Fig. 1 shows a railway axle and wheel with the brake applied, shown partly in section, and fig. 2 a front elevation of the same, the top quadrant showing the brake removed. A is a wrought iron ring fixed to the face of the wheel, and forms the armature. D is a wheel-shaped casting which does not revolve with the wheel, being prevented from so doing by tie rods attached to lugs, K. The rim, D, has a groove, E, in which a coil of insulated copper wire is wound, and two iron rings, F and F′, are fixed to the face, which become opposite poles when a current flows, the brake is then attracted to the armature, A, and enormous friction is produced between the large surfaces in contact, so stopping the train. Tests were arranged by Mr. E. R. Dolby for the patentees, and were carried out upon the main line of the London and North-Western Railway, between Adderley Park Station, Birmingham, and Stechford, which is an almost straight and level section, upon Sunday, December 8th, 1889, as during the week the line is too fully occupied with traffic to be available. A 3rd class railway carriage with four wheels was fitted with a brake on each wheel, the brakes on each side being in series and the two groups in parallel; the two on each side were linked together by tie-rods to prevent rotation, thus taking all strain off the framing of the vehicle; a secondary battery, consisting of 17 cells of the E.P.S. type, was placed in one of the compartments, and a switch, ammeter, and voltmeter were fixed in position; the length of the body of the vehicle was 30 feet, wheel base, 14 feet, wheels 3 feet 6 inches diameter. The trial train consisted of:

	Tons.	cwt.	qrs.
1 locomotive, No. 670, L. & N. W., and 1 carriage fitted with brakes, weighing ...	8	19	2
9 persons in carriage, at 10 stone each ...	0	11	1
	9	10	3
1 ordinary brake van, L. & N. W., 6 wheels, body 30 feet long, wheel base 17 feet 10 inches, and weighing	10	0	0

and was arranged locomotive first, then the brake-test carriage, and last, the ordinary brake van. A slip coupling was provided between the locomotive and carriage by which at a given signal the engine could be freed. The train started at a convenient distance before a one-quarter mile post, and then for calculation of speed, the exact time occupied in covering the distance between two one-quarter mile posts was noted in seconds. A fog signal was placed upon the line to give the exact moment for the release of the slip coupling, and when the man in charge of the coupling gave the signal that it was free, the whistle on the locomotive was sounded as a signal for the application of the brake. At the same instant another observer marked the point opposite the window of brake compartment, and from this point the distance was measured to the point where the carriage was pulled up, and taken as the measure of the braking force applied. The resistance of the four brake coils together was about 1·6 ohms. Some of the results are given in the table below.

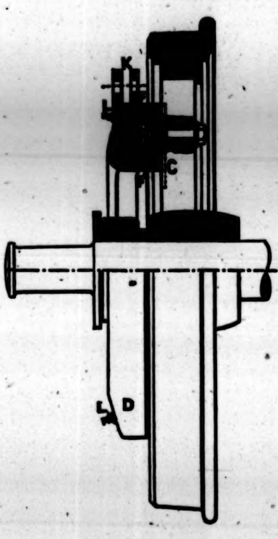


FIG. 1.

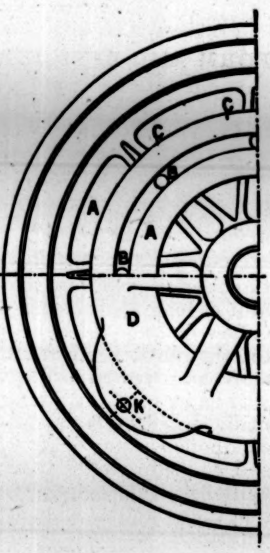


FIG. 2.

Test.	Distance travelled for noting speed.	Time occupied in seconds.	Speed in miles per hour of carriage at moment of braking.	Distance travelled by carriage after application of brake.	E.M.F. in volts.	Amps. of current.	Remarks.
			Adderley Park to Stechford.				
1	½ mile	60	30	258 yds.	32	20	Van & carriage.
2	¼ „	30	30	240 „	„	„	„ „
			Arrived at Stechford—brake van taken off.				
3	¼ „	32	28	76 „	32	...	Carriage alone.
4	¼ „	29	31	155 „	„	20	Skidded.
5	¼ „	25	36	140 „	...	...	„
			Back to Stechford—starting again towards Adderley Park.				
6	½ „	43	42	204 „	32	19	Not skidded at all.
7	½ „	46	40	340 „	12·5	6·5	
8	¼ „	25	36	112 „	20	10	
9	½ „	45	40	200 „	19	10	
			Back to Stechford—van connected again.				
10	½ „	45	40	330 „	30	16·5	Carriage & van.
11	¼ „	29	31	290 „	„	„	
12	¼ „	24	37·5	310 „	„	„	
13	¼ „	27	30·5	240 „	31·5	18	

The variation in the electromotive force was obtained by altering the number of cells in use, an ordinary switch was used for which in practice will be substituted a switch with adjustable resistances. The disagreement in some of the results is brought about partly by the temporary arrangement of the brakes which prevented them always coming on equally well, and by the state of the rails, as there was a keen frost and about one inch of snow lying at the time.

The brake is specially intended to be used in conjunction with Mr. I. A. Timmis's well known system of lighting trains by electricity, and a very noticable feature in its action is the entire absence of the usual jarring sensation on application of a brake. Trains are now being fitted up with it throughout in Russia and elsewhere, and the action is instantaneous throughout the train, also if a carriage should become disconnected it is automatically brought to rest.

FORM AND EFFICIENCY OF INCANDESCENT FILAMENTS.

By CHARLES J. REED.

(*Concluded from page* 704.)

FORMS OF CROSS SECTION.

Of all possible forms of cross section the circular has the largest area for the same radiating surface per unit of length, and, consequently, has the advantage of great strength. The current density will also be less in this than any other form; and hence any "disintegrating" or "electrolytic effect" of the current, if there is any such, will be least in the cylindrical filament. This will be made clear by supposing a number of lamps of equal candle-power to be burning at the same temperature and pressure, but having various forms of filament, cylindrical, flat, square, &c. We have already seen that these lamps all consume equal amounts of energy, and since they have the same pressure, they must take the same current. Therefore, the filament which has the greatest area of cross-section will have the least current density. The fact that the cylindrical filament has the greatest cross-section does not signify that it will require a greater current to keep it at the same temperature. Its form is better adapted for retaining heat than any other. Again, the several lamps will have equal resistance; otherwise they could not take equal currents with the same pressure. From this it follows that the cylindrical filament will be longer and will have less surface and greater mass per unit of length than any other.

A tubular filament would have a greater external diameter, but smaller cross-section of material, and would be shorter than the cylindrical.

The advantages and disadvantages of the various forms may be summed up as follows:—

The cylindrical has the advantage of greater strength and less current density on account of greater cross-section. It has the disadvantage of greater length and fragility.

The tubular filament is strongest in form, being shorter and of greater external diameter than the cylindrical. It has the disadvantage of greater current density than the cylindrical. Both the tubular and the cylindrical have the advantage of uniform illumination in all directions except in and near the plane of the filament.

Flat, or angular filaments have the disadvantage of great current density, and of being unequally heated, since the edges or projecting corners will always be a little cooler * than the other parts.

A short, thick filament has the advantage of being stronger and more durable than a long, slender one; but the disadvantage of wasting a greater percentage of heat by conduction through the terminal wires. In this latter respect it is true that the long filament is slightly more efficient than the short. A 10-ampère filament a foot long would waste no more energy by conduction than a 10-ampére filament an inch long.

Aside from the difficulty of obtaining lamps of different types from different makers which have the same specific resistance and radiating power, there is the difficulty, or rather the impossibility, of getting them all to burn at the same temperature, and the difficulty of knowing, even approximately, what that temperature is, and whether it is the same in two lamps or not. For these reasons no experimental comparisons yet published are of any value, either in corroborating or refuting these conclusions. There is one method, however, of testing the formulæ. This method the writer has tried upon some twenty-five different types with the most satisfactory results. The method is as follows:

A lamp is constructed with a filament of known dimensions, treated to the required process, and exhausted to a certain pressure, as determined by a McLeod vacuum gauge. It is then placed on a circuit of a certain pressure, which gives it a certain desired temperature or efficiency, and the candle-power and current are measured. From the data thus obtained we calculate by the above equations all the data for lamps of other types. The lamps when made according to this data from the same material by the same process, and exhausted to the same pressure should give the calculated candle-power at the calculated pressure.

HEAT LOST IN WIRES.

It must be remembered that the formulæ take no account of the small amount of heat that escapes by conduction through the wires. With lamps of high resistance this may safely be ignored in practice, but in changing from a long to a very short and thick filament, it must be taken into account.

The following examples may serve to better illustrate the method:—

Let us suppose a lamp has been constructed to give a certain candle-power on a circuit of a given pressure, and it is desired to construct other lamps having the same efficiency (temperature) and life, but of different candle-power, for the same or for different pressure. We will call this lamp for convenience the zero lamp, and denote its particular values of the variables by the subscript, O.

Let $C = C_o =$ 16 candles.
$c = c_o =$ ·6 ampère.
$E = E_o =$ 100 volts.
$R = R_o =$ 167 ohms.
$L = L_o =$ 170 millimetres.
$r = r_o =$ ·07 millimetre.

DETERMINATION OF CONSTANTS.

The constants, K, K', K'', S and S', will have the same value for all values of C, c, E, R, L and r, and hence will be found by substituting for these quantities the simultaneous values, C_o, c_o, E_o, R_o, L_o and r_o, respectively.

If H is measured in horse-power, we have from (1) $K = \frac{1}{746}$. From (4)

$$R_o = S' \frac{L_o}{\pi r_o^2}$$

or

$$S' = \frac{\pi R_o r_o^2}{L_o} = \frac{\pi \times 167 \times (\cdot 07)^2}{170} = \cdot 015122,$$

from (3)

$$K' S = \frac{K E_o c_o}{2 \pi r_o L_o} = \frac{100 \times \cdot 6}{746 \times 2 \pi (\cdot 07) \times 170} = \cdot 0010757,$$

from (15)

$$K'' = \frac{C_o}{2 \pi r_o L_o} = \frac{16}{2 \pi (\cdot 07) \times 170} = \cdot 21399.$$

---

* It was asserted before this institute, June 8th, 1886, that the edges or corners of a square filament are hotter than the remainder of the surface; but no reason was given. Such a statement scarcely needs refutation, being contrary, not only to established laws, but to the most commonplace and everyday experience. We need only observe the cooling of a square bar of red-hot iron to convince ourselves that the sharp corners are the coolest parts. And they would remain the coolest parts even if the heat were continually supplied by an electric current to the interior of the bar.

Substituting these values of K, K″, S′ and K′ S in equations (4) to (25), we are enabled to solve any problem involving R, E, C, r, c, and L, when any two of the quantities except c and r are given. The equations apply only to lamps of the same material and at the same temperature as the zero lamp. By starting with a lamp of different material, or by burning the same lamp at a different temperature, we obtain a different set of constants, which substituted in equations (4) to (25) adapt them to the changed conditions.

Suppose we wish to construct a lamp of 20 candle-power for a 90 volt circuit:

$$C = 20.$$
$$E = 90.$$

From (21)

$$c = 3{\cdot}75 \tfrac{20}{90} = {\cdot}8333 \text{ ampère}$$

from (9)

$$r = {\cdot}098466 \sqrt[3]{({\cdot}8333)^2} = {\cdot}087196 \text{ millimetre}$$

from (11)

$$L = 6{\cdot}4190 \times 90 \sqrt{{\cdot}087196} = 170{\cdot}59 \text{ millimetres}$$

and from (4)

$$R = {\cdot}0048134 \frac{170{\cdot}59}{({\cdot}087196)^3} = 108{\cdot}00 \text{ ohms.}$$

The calculations may be verified by substitution in some of the other formulæ.

In constructing the lamp we take a filament 170·59 millimetres long, and of such a radius that, when treated to the given process until at the proper exhaustion it takes ·833 ampère with 90 volts, it will have a radius of ·0872 mm. If the treatment of the carbon does not increase its diameter, the initial and final radius will be the same; but the radius of the *finished carbon* is to be ·0872 mm. When these conditions are fulfilled, we know with certainty that the lamp has the proper temperature if it gives 20 candles. If any single condition is not fulfilled, we know with the same certainty that the lamp has not the proper temperature. If two or more of the required conditions are simultaneously not fulfilled, then we know nothing about the resulting temperature.

LIFE AND EFFICIENCY.

We are thus enabled to construct lamps of uniform life for varying conditions of current and candle-power; and also to regulate the length of life and the efficiency, increasing or diminishing either the life or the efficiency at pleasure to suit the requirements of particular conditions, remembering always that the life and efficiency are inverse functions of each other.

The fact that the life of most commercial lamps is very irregular, shows that either the material or the temperature is not uniform, and hence, that there is lack of uniformity either in the process or in the dimensions. The writer has examined a number of different makes of lamps, and found that they generally vary in length and cross-section enough to produce serious differences in temperature.

Suppose, again, we wish to construct a 50-candle lamp for a series circuit of 5 ampères:

$$C = 50.$$
$$c = 5.$$

From (20)

$$E = 3{\cdot}75 \times \tfrac{50}{5} = 37{\cdot}5 \text{ volts.}$$

from (9)

$$r = {\cdot}098466 \sqrt[3]{(5)^2} = {\cdot}28792 \text{ millimetre.}$$

from (11)

$$L = 6{\cdot}419 \times 37{\cdot}5 \sqrt{{\cdot}28792} = 129{\cdot}16 \text{ millimetres.}$$

from (4)

$$R = {\cdot}0048134 \frac{129{\cdot}16}{({\cdot}28792)^3} = 7{\cdot}5 \text{ ohms.}$$

In this case the loss of heat by conduction through the connecting wires is considerable, and must be taken into account.

The above equations are not limited to incandescent filaments, but apply equally to any conductor which may be kept at a certain fixed temperature by an electric current. By using the proper constants, useful formulæ may be derived for calculating conductors, so that under given conditions they will be heated to a required temperature.

A METEOROLOGICAL PHENOMENON.

A RECENT issue of the *Gaceta Oficial*, of Madrid, contains an account of an extraordinary occurrence which took place at Pontevedra, a town of the province of Galicia, Spain, at about 9·45 p.m. on December 2nd. The description of the incident was contributed to the *Gaceta Oficial* by D. Ernesto Caballero, professor of physics and manager of the electric lighting manufactory at Pontevedra.

It seems that at the time above stated the sky being clear and calm, a ball or globe of fire, about the size of an orange, was seen to fall upon the network of overhead electric wires which stretch over the town, and selecting as its course the lines which led to the before mentioned factory, entered the building by an open window in the wall on the north western side. The first appearance of the phenomenon inside the factory was on the switchboard, from whence, lifting in its passage the armature of a magnetic short circuit or cut-out, it jumped on to a dynamo in full work. The astonishment of the engine driver and workmen in the neighbourhood can be imagined on seeing the globe jump twice backwards and forwards between the dynamo and the switchboard, finally landing on the ground where it burst with a loud, sharp explosion into innumerable fragments. No damage was caused and the various particles of the globe rapidly extinguishing left absolutely no trace of their short existence.

Thanks to the coolness of the *employés* in the factory, who with admirable promptness took the necessary steps to ensure the continuance of the electric light throughout the town, only a momentary interruption was experienced.

On close examination the only traces left of the mysterious visitor, were in the fused edges of two thick copper plates attached to the armature, which was raised. Outside the works the meteor was seen by several persons and on examining the overhead wires on the following day, unmistakable evidence was found of the electrical nature or origin of the phenomenon, such vestiges of its presence as remained being incomprehensible under any other hypothesis.

THE PROTECTION OF TELEGRAPH AND TELEPHONE LINES AGAINST ELECTRIC LIGHT WIRES.

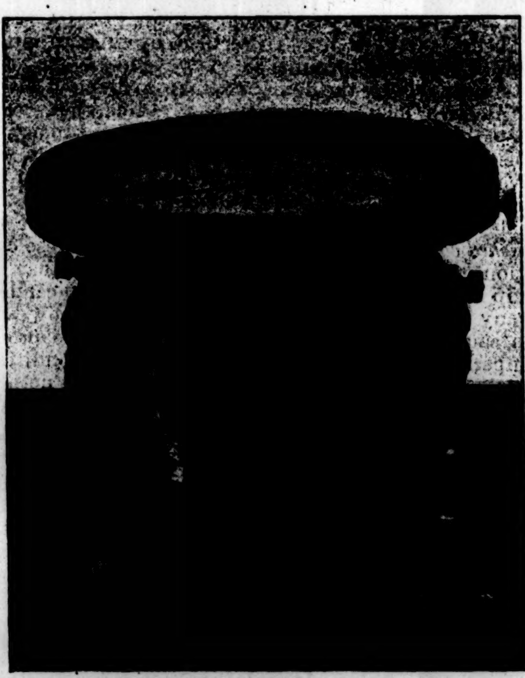
THE Italian Government has recently taken measures to protect telegraph and telephone lines against the harmful influences of electric light systems and other industrial applications of electricity. In connection with this subject, the *Elektrotechnische Zeitschrift* gives the following particulars of the measures taken by the Italian Government:—

The lines used for electric lighting, or for other industrial objects, must form a closed metallic circuit, and having no earth contact throughout its length. It is forbidden to attach them to water or gas mains. The conductors of electric light systems situated in the neighbourhood of a telegraph or telephone line must be covered with a substance impermeable to water, and sufficiently ensuring their insulation. In places where the workmen of the Telegraph or Telephone Administration would risk, in the course of their work, coming in contact with electric light conductors, the latter must be provided with a special insulation, and placed far enough from the telegraph or telephone lines, so that a simultaneous contact with the wires of each other cannot take place. Immediate contacts between electric light wires and those of the telegraphs and telephones must be absolutely impossible, either in the normal state of the wires, or in the event of a breakage of the wires. The lines must be constructed under such conditions of solidity that they are capable of resisting all the attacks to which they are likely to be exposed. In case of need they must be supported throughout their length by cables of suitable strength. It is necessary to avoid, as much as possible, the running of electric light lines parallel with those of the telegraph and telephone. When a parallel course is inevitable, the electric light lines must be kept at a distance of at least 12 metres from the telegraph and telephone systems. At the points of intersection, the electric light wires must pass below and at right angles to the telegraph or telephone lines. The distance between the lowest telegraph or telephone conductors and the nearest electric light wire must be at least two metres. The posts or supports of the electric light conductors must be, at these crossing points, kept at a distance of at least three metres from the telegraph or telephone lines. In order that the latter shall not, in case of breakage, come in contact with the electric light lines, a safety wire of sufficient strength must be placed immediately over each electric light conductor throughout the whole of the crossing. Those establishing or working a system of electric lighting must take all the precautions of which science and experience have proved the utility. They must bring all their care to bear on the maintenance of their lines, which must be daily subjected to a minute inspection, and be kept constantly in a good state of repair. The constructor will be responsible for all damages and accidents caused by the system of electric lighting. The Government reserves to itself the right of altering or replacing the dispositions of the ordinance on which it acts, as well as of transferring or suppressing the electric light lines if the contractor should not immediately execute the orders given him by the Administration, and that without any claim lying for indemnity. The telephone companies may demand the application of the latter disposition, as well as that relative to the distance of the electric light conductors at the point where they cross the telephone lines, simply on condition of supplying proof that the proximity of the electric light lines is hurtful to their telephone lines, which were established first. As far as regards the telephone lines which may be established afterwards, their owners must see themselves that they are placed at a suitable distance from the electric light lines. When a contractor for the electric light wishes to have his lines transferred into the proximity of telegraph or telephone lines, or to introduce changes into an already existing line, he must for that purpose obtain the authority of the Telegraph Administration. The contractor will have to bear all the expenses resulting from the execution of measures of precaution or of transfer of telegraph, telephone, or electric light lines. The Telegraph Administration itself may eventually execute these works at the contractor's expense. If the above dispositions be not applicable to certain particular cases, the Telegraph Administration reserves to itself the right of examining the propositions of those interested, and of approving them or rejecting them, as it deems most suitable.

Electricity in Naval Warfare.—The six first-class torpedo boats recently built for the Admiralty by Messrs. Yarrow & Co. represent the latest type and most improved construction of "sea-going" torpedo boat. They are fitted, amongst other things, with electrical search lights; and for the production of electricity there is a dynamo and engine in the galley compartment.

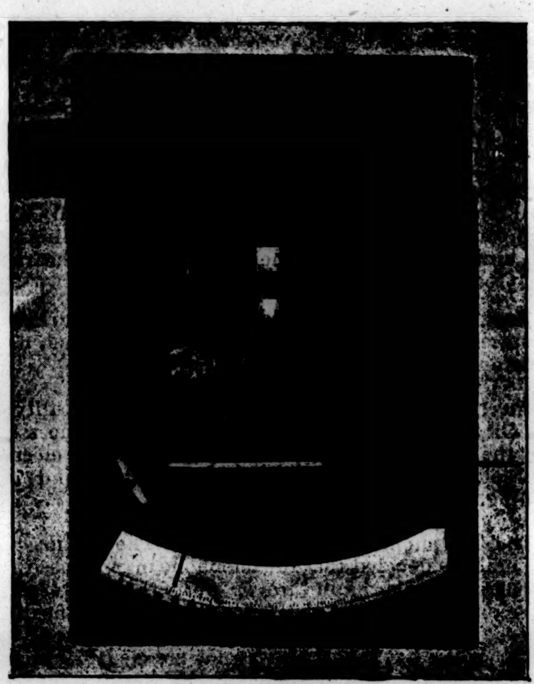
SIR WILLIAM THOMSON'S NEW INSPECTIONAL ELECTRIC INSTRUMENTS.

THE Magneto-static Current Meter consists essentially of a small steel magnet or system of magnets suspended in the centre of a uniform field of force due to two coils, each having one or more turns of copper ribbon or wire, and also under the directive influence of two systems of powerful steel magnets. The suspended system of magnets is attached to one end of a vertical shaft passing down centrally through an opening in the sole plate of the instrument from an indicating needle. The two systems of directive magnets are circular in form, and each ring is composed of two semi-circular magnets placed in a brass cylindrical frame with their similar poles together. Each system is securely fixed to a circular brass frame, which fits on to the cylindrical case of the instrument in such a manner that the systems are capable of being turned round, together or separately. The instrument has a "tangent scale consisting of 100 divisions," which is adjusted in its position before the instrument is sent out, so that the needle indicates equal differences of readings for equal differences of current.



THE MAGNETO-STATIC CURRENT METER.

The instrument has an advantage, important for some practical purposes, of being available as an accurate direct-reading current meter, through a continuous range of from one to 100 times its smallest current, which may be anything from half a milliampère to four ampères, according to the number of turns in the coils supplied with the instrument. It is not, however, available as an alternate current instrument, and it must be remembered that the magnetism of the steel-directing magnet does not remain *absolutely* constant. With good quality of steel, a proper preliminary *ageing* of the magnet (by heating it several times in boiling water and cooling it again, and subjecting it to somewhat varied rough usage) brings it to a condition in which its magnetism is found to remain exceedingly nearly constant month after month and year after year. Still it should never be relied upon as *absolutely* constant, and for accurate laboratory work it is therefore necessary to have some means of retesting the instrument at any time. Another advantage which the instrument has is that, when a standard instrument is available, its constant is capable of being varied to any desired value down to one-tenth of that which it has with its directive magnets in their strongest position. Thus if the constant should be three ampères per division of the scale, with the similar poles of the magnets coinciding, it may be adjusted to any value down to 0·3 ampère per division. The two grades of this instrument which are found most convenient are:—The milliampère-meter, which has an effective range of from ·3 to 300 milliampères, and is usually adjusted to read two milliampères per division, and the ampère-meter, which has an effective range of from ·3 to 300 ampères, and is usually adjusted to read one ampère per division. One very convenient use of the latter instrument is to act as a lamp counter for indicating the number of incandescent lamps in use in an installation. For this purpose it is best to standardise it by putting on a known number of lamps and adjusting by the magnets until the desired reading is obtained on the scale. Of course this numbering of lamps is not possible to any great accuracy, because the lamps themselves are not all rigorously equal in the amount of current which each takes, but the lamp counter serves the important practical purpose of showing at any time the number of lamps in use nearly enough for practical purposes. The milliampère-meter, on account of the low resistance of its copper coil—about 40 ohms—may conveniently be used as a voltmeter. To adapt it for this purpose a copper cylinder, wound anti-inductively with two platinoid resistances, is supplied. The first of these, together with the resistance of the instrument, makes up 100 ohms, and the second alone is 900 ohms. Thus, taking the constant of the instrument at two milliampères per division, by joining the smaller in series with the instrument, the reading on the scale will be ⅕th of a volt per division; with both resistances in series with the instrument the reading will be two volts per division.



The Ampere Gauge.

The Ampère Gauge is of simple construction, having a vertical base-plate of paraffined marble, to which are attached:—(*a*) A solenoid of special form; (*b*) Brass bearing plates supporting a balance which carries a soft iron plunger on its one arm and a brass counterpoise weight on the other; (*c*) A brass arc having a scale graduated to give direct readings in ampères; (*d*) A hinged arm which bears a light checker. The solenoid is built up of copper plates with mica insulation between them, and is fixed to the base plate so that its core is vertical. The balance is supported on knife edges at such a distance below the solenoid that the top end of the plunger is slightly entered into the core. The plunger is made from a thin soft iron wire about 20 centimetres long, and is supported by a cross-bar with two hooks on it which pass over two knife-edge stirrups on the arm of the balance. It has a brass weight hung on its lower end in order to keep it in a vertical position and prevent its being attracted against the side of the solenoid. An indicating needle, or pointer, formed from a strip of platinoid, passes down from the trunnion of the balance to the brass arc bearing the graduated scale. As the plunger is attracted upwards this pointer passes round the scale and indicates the strength of current passing through the solenoid.

Several types of the Ampère Gauge are made covering a range from 0·5 to 500 ampères, and are available as measurers of electric current on either direct or alternating circuits. They are standardised by direct comparison with Sir William Thomson's standard electric balances, and when the instrument is intended for alternating currents the graduation is made to suit the period of alternation in use on the circuit for which it is desired.

SUBMARINE BOATS.

News from Toulon, dated December 20th, confirms the reports as to the success of experiments conducted by Admiral Duperre with the submarine vessel, *Gymnote*.

We learn that this boat has navigated under water for a distance of three-quarters of a mile, her movements being completely under control. On December 19th, she traversed the harbour, under water, in every direction, steering clear of the numerous buoys and moorings, and passing under several ironclads. A structure called the "periscope" permits the officer in charge to distinguish objects on the surface while the boat is being manœuvered at a considerable depth.

The long delay which has been experienced in bringing this vessel into a forward state, was due to the difficulty met with in discovering some suitable material for the cases of the accumulators. These cases were at first constructed of metal, neither glass nor pottery being considered sufficiently strong to resist vibration and possible shocks, but a composition, principally consisting of India-rubber, has been discovered, which is said to answer all requirements.

At the same time we read of the experiments which are being conducted at Cadiz with the submarine vessel, the *Peral*. The results, however, do not appear to have been so successful as those in the case of the *Gymnote*, since the Spanish boat has not yet attempted to navigate any distance under water, all that has yet been done being simply to submerge her to an inconsiderable depth, and to manœuvre her with the hull under water but having the conning tower above the surface. The reason that experiments as to her capabilities of progression when completely submerged have not yet been undertaken, is stated to be the withholding of permission to that effect by the authorities in Madrid.

SUBWAYS.

The annoyance and inconvenience caused by the digging up of the roadways and pavements for the purpose of gas and water repairs have often been a cause of complaint, and if there has been just reason for this in times past, there will be much more in the future. We have beneath the soil not only gas and water pipes, but telegraph wires, pneumatic tubes, electric light wires, and hydraulic power mains; steam supply pipes have not yet been laid down, and probably the difficulties of want of space would render such an idea almost impracticable, if it were entertained at all. The only real cure for the evils inherent in the present crude system of placing pipes out of the way is the construction of subways—along the main thoroughfares, at least. The expense, no doubt, of such a scheme, if extensively carried out, would be enormous; but the value of the arrangement would be undoubted, and the companies who now have to spend much money in digging up and making good the roadways, would, we should imagine, be quite ready to pay a rental for the convenience afforded them. Probably, again, the existence of spacious subways would stimulate new forms of industry in which the transmission of power in some form or other is employed. Although, no doubt, the County Council would be the proper authority to undertake the construction of subways, there seems no reason why the work should not be delegated to a company who could charge a rental for the space afforded, though it would of course be a question whether a sufficient return for the capital expended could be secured. Supposing a company did undertake the work, the ratepayers would probably not be disinclined to bear a certain portion of the expense in consideration of the abolition of the continual disturbance of the streets which now takes place, and which would, if the subways were constructed, become a thing of the past. Should the projected electric railway to the West of London be ever carried out it might be worth considering whether the construction of a subway might not form part of the scheme, for it must be obvious that the saving of cost of construction in such a case would be very considerable. Much has been said in the press with reference to the danger caused by the accumulation of gas in subways through which electric light wires pass, but it seems difficult to believe that this danger could not be effectually guarded against by a system of good ventilation, about the carrying out of which there ought not to be the least difficulty.

NOTES.

The Board of Trade and Electric Lighting.—The Board of Trade has found it necessary to augment the accommodation of the Electric Lighting Department, which will accordingly be shortly transferred to more commodious premises, No. 8, Richmond Terrace, formerly occupied by the Royal Commissioners. The Labour Bureau of the Board will occupy the vacated offices in Bridge Street.

Huddersfield Electric Lighting.—The Huddersfield Town Council has resolved to apply for a provisional order authorising the erection and maintenance of electric lines and works for the supply of electricity within the borough.

The Electric Lighting of Windsor Castle.—The electric lighting of the grand corridor is said to be so highly successful that probably it will be soon extended to the dining room and the three drawing rooms.

Electric Lighting at Leeds.—The Parliamentary Committee of the Leeds Corporation is to confer with the Electric Lighting Committee with reference to the action of the Corporation on the application of three companies, viz., that of the Yorkshire House-to-House Electricity Company, Limited; the National Electric Supply Company Limited; the Electric Installation and Maintenance Company Limited, for provisional orders authorising them to supply electricity within the borough.

Electric Lighting at Barnsley.—The Barnsley Cooperative Society has decided to adopt the electric light at its stores. The installation will consist of 19 lamps of 100 candle-power, 65 lamps of 50, four of 32 each, and 142 of 16, making a total of 7,482 candle-power.

Electric Lighting Troubles in New York.—The correspondent of the *Daily News* wired on Sunday night:—"Most of the electric lighting wires upon poles have been cut down by the authorities, and the operation will be continued till all those considered dangerous have been removed. Several electric lighting companies have practically gone out of business, gas being substituted as rapidly as possible for street lighting, but only temporarily. The electric lights are certain to be restored at an early day, but in a safe form.

The Lighting of Parliament.—The City of Westminster Electrical Syndicate, Limited, is lighting the Houses of Parliament, not the Westminster Electric Supply Corporation, as is generally supposed.

The Electric Lighting of Hove.—The Hove Commissioners are about to memorialise the Local Government Board for a provisional order for electric light.

Electric Lighting Accident in Madrid.—On Monday night the audience at the Madrid Opera House had to quit hurriedly, an accident to the electric light machinery rendering further performance impossible. It was said that two persons had been injured behind the stage.

Danger Ahead.—The *Standard* of Christmas Day devoted a column and half to a dissertation on the dangers of electric wires. There is nothing to be learned from it; but it is significant that the daily Press of this country is becoming alarmed, and not without reason.

Christmas Greeting.—We have received a Christmas card from the New York staff of the Commercial Cable Company, which is one of the most tasteful things of the kind we have seen. Their good wishes are heartily reciprocated.

Removal.—Mr. A. P. Lundberg has removed to larger business premises at Bradbury Street, Kingsland, near Dalston Junction, N.L.R.

Electric Lighting of Florence.—The municipality of the City of Florence is inviting tenders for a concession for the production and transmission of the electric current, both for purposes of illumination and impelling power for the use of the public.

The Telephone as a Fire Alarm.—The Postmaster-General has decided that the telephone may be used for transmitting alarms of fire or rioting. The question arose on a decision of the Leicester postal authorities that, as the fire did not originate on the premises of the renter of the telephone, he was not entitled to use the instrument for the purpose of informing the fire brigade, its use being restricted "to his own business and private affairs." The question is one of grave importance to the commercial public.

Copper Mining in Ireland.—A company is being formed for the working of a copper mine between Dunmanus Bay and Crookhaven, co. Cork. The South of Ireland is said to be rich in mineral wealth, requiring only capital and enterprise to develop it.

Electricity in Liverpool.—The Liverpool Electric Supply Company will open its extensive new premises in Tithe Barn Street early in January. The new premises will consist of a supply station, construction works, a board room, and a handsome suite of offices.

The Institute of Patent Agents.—The first qualifying examination for certificates entitling to admission to the Register of Patent Agents, established under the Act of 1888, was held November 18th to 23rd, by the Institute of Patent Agents, under the regulations passed by the Institute and approved by the Board of Trade, in accordance with the Register of Patent Agents Rules, 1889. The successful candidates were:—Mr. Thomas Henry Barron, of Huddersfield, and Mr. George Beloe Ellis, of London.

The Telephone in Court.—On Friday Mr. Justice Chitty made an order committing one Robert Norton to prison for disobeying a judgment restraining him from infringing telephone patents vested in the United Telephone Company. It was proved that he had supplied receivers identical with Bell's.

Logical.—In the *Patent Journal*, just issued, we find the conclusion of a report in a patent case, and we quote the following remark of a learned judge, which, for lucidity and correctness, might have been mistaken for an extract from "Proverbial Philosophy":—"If it prejudices you, you will be prejudiced. If it does not, you will not be."

New Address.—Owing to increasing business Mr. Harry South has found it necessary to remove from 10, John Street, Adelphi, to more spacious premises at 10 and 12, Garrick Street, Covent Garden, where he is also establishing show-rooms for all kinds of electric lighting material.

Transformer Patents.—The Westinghouse Electric Company has, according to notices in the American technical press, fared no better than a great number of the old electric lighting companies in this country. The sum of $900,000 is said to have been paid for the purchase of the Gaulard and Gibbs series transformer system; a system which has never been tried by the Westinghouse Company, and is not likely to be, since all its installations have been erected on the multiple system.

The Construction of Motors.—In order to obtain the maximum effective work out of a given weight of copper and iron in an alternating current motor, or any direct current motor, Mr. Nikola Tesla reasons that in any motor the total energy supplied to do the work is equal to the sum of the energies expended in the armature and the field. The power developed, however, is proportionate to the product of these quantities. This product will be greatest when these quantities are equal; hence in constructing a motor Mr. Tesla determines the mass of the armature and field cores and the windings of both, and adapts the two so as to equalise as nearly as possible the magnetic quantities of both. In motors which have closed armature coils, this is only approximately possible, as the energy manifested in the armature is the result of inductive action from the other element; but in motors in which the coils of both armature and field are connected with the external circuit the result can be much more perfectly obtained. In further explanation of this, says the New York *Electrical World*, let it be assumed that the energy as represented in the magnetism in the field of a given motor is 90 and that of the armature 10. The sum of these quantities, which represents the total energy expended in driving the motor, is 100; but, assuming that the motor be so constructed that the energy in the field is represented by 50 and that in the armature by 50, the sum is still 100; but while in the first instance the product is 900, in the second it is 2,500, and as the energy developed is in proportion to these products it is clear that in any motor the best conditions are obtained when at normal load the magnetic quantities in field and armature are equal. These results Mr. Tesla obtains by using the same amount of copper or ampère turns in both elements when the cores of both are equal and the same current energises both; or in cases where the currents in one element are induced to those of the other, he uses in the induced coils a proper amount of copper. What do Profs. Ayrton and Perry say to this, for is not their theory that the field shall be a strong magnet while the armature is relatively weak?

City Fires.—Mr. Ferranti's premises in Charterhouse Square were damaged on Christmas Day by the great fire which occurred in the same block of buildings in which he carries on his business.

Obituary.—We regret to announce the death of Mr. W. Stroudley, late locomotive engineer of the London, Brighton and South Coast Railway. Mr. Stroudley will be best known to the readers of the REVIEW as joint inventor with Mr. Houghton of a system of railway carriage lighting by electricity. The deceased gentlemen was interred in Preston Churchyard, Brighton, on Tuesday last.

Earthing Devices.—Mr. Bernard Drake had a lengthy letter in yesterday's *Standard*. After reviewing the dangers attached to the use of the converter system, he winds up by telling us that we can employ high-tension currents with an easy conscience, so long as we include Major Cardew's "earthing device" in the system. We trust that Mr. Drake is correct, but we have yet to learn the practical value of this invention. Anyhow, he has chosen an opportune moment to trumpet forth a warning note.

The Bradford Electric Supply.—The Bradford Museum is now electrically lighted, and for it is claimed the honour of its being the first public building supplied by a Corporation which also supplies the public requirements. These, it may be mentioned, are at present greater than the station can adequately supply.

Presentation.—The employés of the Electrical Construction Company (late Elwell-Parker, Limited), have presented Mr. Thomas Parker with a framed and illuminated address, together with a beautiful silver tea service. It is pleasing, in these days of open rupture between master and man, to see such harmony prevailing as exists in the Wolverhampton firm, and in thus honouring Mr. Parker the men do honour to their own intelligence and appreciation of his efforts to promote the electrical industry and their interests, while, at the same time, advancing his own.

Correction.—Mr. R. D. Smillie wishes us to state that the contract for lighting the "Moss line" steamers, which we mentioned in our last, was secured by Messrs. J. H. Holmes and Co., of Newcastle, whose firm is represented in Scotland by our correspondent.

National Telephone Electrical Society.—Mr. Loftus, the construction inspector of the National Telephone Company, read a paper before this society on Friday evening, the 20th inst., on "The Construction and Maintenance of Telephone Lines."

L'Electricien for 1890.—Our contemporary, *L'Electricien*, will commence the tenth year of its existence with an extension of its pages, which will admit of its including original contributions of considerable length without undergoing the curtailment which has hitherto been necessary, and has somewhat detracted from their value. It will now be possible to publish an entire article of 16 to 20 pages in a single issue. The price remains as before.

"Electrical Industries."—This is the title of yet another technical journal devoted to electrical interests. It hails from Chicago, is to appear monthly, and, so far as we can judge from the first number, it will be able to hold its own against its older and established rivals. A novel feature of its contents is a directory of manufacturers and dealers, another of electric light stations and electric railways in North America, and a third of electrical associations.

Mill Fires.—Another instance occurred last week of the burning of a mill through a gas fault; this occurred at the Albion Spinning Company's mill, Atherton. The fire commenced in the attic, and its supposed cause was the falling of a gas jet on one of the mules, setting fire to the cotton. In two hours the main building was destroyed. Damage to the extent of several thousand pounds was done. The property was insured in five offices, and the company were in treaty with a firm for the supply of automatic sprinklers.

Explosions in Subways.—The following telegram from New York appeared in the *Standard* of Tuesday evening, dated Sunday night :—"Explosions in the subways designed to carry the electric wires underground are becoming alarmingly numerous. The cause is supposed to be the filtering in of gas from leaky mains, which is exploded by a casual spark coming sometimes from electricity. Last night, without the least warning, a considerable length of pavement, amounting to several tons weight, rose many feet in the air, amid a geyser of flame. Many pedestrians had their clothes and their persons injured by the subsequent fall of the *débris*. Experts having testified that no insulation can permanently and infallibly confine electricity under a high tension, the gas interests are elated, and the public bewildered between a dislike of gloomy nights and a fear of a sudden and mysterious death."

Co-operative Telephones.—A meeting for the purpose of receiving the report of the committee appointed to consider the desirability of establishing a mutual economic system of telephones in Manchester and elsewhere was held in the Memorial Hall, Manchester, on Monday afternoon last, Mr. A. D. Provand, M.P., in the chair. The report of the committee was read. It dealt with the probable outlay and receipts of the proposed company, and recommended the formation of a company with limited liability. The proposed capital was £100,000, in shares of £10 each; £20,000 will be a sufficient first outlay for Manchester. The headquarters of the company are proposed to be in London, with local committees in Manchester and other places. Six per cent. is fixed as the dividend to be paid on the paid-up capital. A resolution approving the establishment of the company was carried unanimously, and a committee appointed to carry it out.

The Telephone at Fires.—The value of the telephone as a fire alarm has been recently illustrated at Forest Hill. By its means an outbreak of fire which threatened the premises of a local firm was suppressed without much difficulty. The telephone had only been fixed the day before.

Electrical Supplies Wanted. — The Great Indian Peninsula Railway Company requires a supply of telegraph stay rods and battery terminals. Specifications and forms of tender can be obtained at the company's offices 3, New Broad Street, E.C.

Afghanistan Telegraphs.—The Ameer of Afghanistan is stated to be making preparations for an extensive system of telegraphic inter-communication.

Fire in a Meter Room.—A slight outbreak of fire occurred on Wednesday evening, the 18th, in a cellar belonging to the Liverpool and London and Globe Insurance Company, Dale Street, Liverpool. The cellar is used as a meter room for the electric light, and it appears that the fire was caused by an excess of current in the main lead fusing the "cut-out," which was enclosed in a wooden box with a glass frame. The melted metal falling upon the wood, set it on fire. The damage, which was confined to the electrical fittings, amounts only to a few pounds.

The Telephone in Italy.—A Bill is about to be laid before the Italian Chamber of Deputies for making telephonic communication a monopoly of the State.

Electricity and Aluminium.—Says *Invention* :—"The cheapening of aluminium has led to the proposition to construct arc lamps of this material, as preferable on account of its lightness and qualities of resisting rust, in comparison with iron, steel, or brass for outdoor use."

Ship Lighting.—The Red Star new Atlantic liner *Waesland* has been fitted with a complete installation of electric light by Messrs. J. H. Holmes & Co., of Newcastle, London and Glasgow.

Telephone Extension.—Direct telephone communication has been established between Sheffield and Manchester, and will very shortly be opened between Mansfield and Sheffield. Hitherto Sheffield has been connected to Manchester and Lancashire towns *viâ* Bradford and Todmorden.

Edinburgh Exhibition, 1890.—The replies which have been received up to the present from the members of the Electrical Trades Section of the London Chamber of Commerce relative to the terms which the committee has negotiated with the Edinburgh Exhibition authorities, indicate that they are favourable to the acceptance of Mr. Lee Bapty's proposals. It is therefore suggested that members who intend to exhibit should send in their entry forms direct to the Exhibition authorities, with the proviso that they do so on the terms of Mr. Lee Bapty's letter to the Electrical Section. The question of appointing technical attendants at the Exhibition on behalf of the section, the choice of judges and tests, will be dealt with by the committee of the section in due course, but intending exhibitors are reminded that applications for space should be made by the 31st instant.

The Manchester Jubilee Exhibition.—The closing meetings of the Executive Committee and Council of Guarantors of the Royal Jubilee Exhibition, Manchester, 1887, were held at Manchester last week. The statement of accounts submitted to the Executive Committee showed a balance in the bank on the 18th inst. of £42,157, and other assets remaining in the committee's possession represented at cost price £1,560—together, £43,707. The committee recommended that the funds, property and effects of the Royal Jubilee Exhibition should be conveyed and paid over to the Whitworth Institute, subject to the following conditions: £10,000 be be appropriated to the Manchester School of Art, £20,000 to the purchase of fine and decorative art for the galleries or museum to be erected in Whitwork Park, Manchester, and the remaining balance to be devoted to the equipment and building of a new technical school, all as part of the Whitworth Institute. The recommendations of the committee was approved, and with a parting vote of thanks to the energetic Chairman, Sir Joseph Lee, the affairs of the Royal Jubilee Exhibition closed. The final results of this exceedingly successful exhibition are most gratifying.

NEW COMPANIES REGISTERED.

Wrexham and District Electric Light Supply Company, Limited.—£20,000, in £5 shares. Objects: to form centres in Wrexham, and within the surrounding Hundred of Bromfield, County of Denbigh, or elsewhere within the United Kingdom, at which electric power may be generated or accumulated, and from which the same may be distributed for public and private lighting, or for giving motive power or heat. Signatories :—H. Venables Palin, Mayor of Wrexham, 5 shares; F. W. Soames, 10 shares; Wm. Lester, 5 shares; R. H. Done, 5 shares; J. Meredith Jones, 10 shares; J. Beirne, 10 shares—all of Wrexham; T. Vaughan Hughes (electrical engineer), Greenfield, Holywell, 5 shares. Registered 19th inst., without special articles of association, by Abbott Jenkins and Co., 8, New Inn, Strand, agents for Lewis and Son, Wrexham.

West London Tramway Company, Limited.—Capital, £2,000 in £10 shares. Objects: to construct and lay down tramways in the County of Middlesex and to equip and work with electricity, locomotive or stationary engines, cable, wire rope, or any mechanical or animal power. Signatories (with 1 share each), S. E. Buttenshaw, St. Albans; E. L. Pellatt, 45, Alexandra Road, N.; William Gunn, 10, Station Road, Harlesden; E. J. Harries, 1, Rochester Terrace, Camden Road; W. H. Glover, 6, Well Walk, Hampstead; F. G. Barrett, Palmer's Green, N.; W. Bell, 97, Richmond Road, Dalston. Registered 21st inst. by E. M. Chubb, 11, Pancras Lane.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Kingston-upon-Hull Electric Lighting and Supply Company, Limited.—The statutory return of this company, made up to the 9th ult., was filed on the 19th ult. The nominal capital is £1,000 in £1 shares, but the only shares at present taken up are the seven subscribed for by the signatories to the memorandum of association, and upon these no call has been made. Registered office, 19, Parliament Street, Hull.

Dutton and Company, Limited (railway signal engineers and electricians).—The statutory return of this company, made up to the 8th ult., was filed on the 12th ult. The nominal capital is £60,000, divided into 5,500 ordinary shares, and 500 £6 per cent. preference shares of £10 each. The shares taken up are 2,910 ordinary and 231 preference. Upon 2,400 ordinary shares the full amount is considered paid up. Upon 500 shares the full amount has been called, and upon 241 shares (including 50 fully paid) the sum of £5 per share has been called. The calls paid amount to £6,440, and unpaid to £30.

Leicester Electric Light and Power Company, Limited.—The statutory return of this company, made up to the 8th November, was filed on the 12th ult. The nominal capital is £1,000 in £1 shares. The only shares at present taken up are the seven subscribed for by the signatories to the memorandum of association, and upon these no call has been made. Registered office, 20, Friar Lane, Leicester.

CITY NOTES, REPORTS, MEETINGS, &c.

The Metropolitan Electric Supply Company.

The second ordinary general meeting was held at Winchester House, Broad Street, on Friday, the 20th, Sir John Pender in the chair.

The Secretary read the motion convening the meeting.

The Chairman said, before asking the meeting to approve the report, it was desirable they should have the very fullest information, not only with regard to the past year, but also as regards their future prospects. The report could scarcely be more complete than it was, but he proposed to some extent to give them still further information, so that they could judge of the foundation upon which they had made their investments. They would have noticed from the report that the whole of the financial year which ended on the 30th of September had been taken up in obtaining Parliamentary sanction for their schemes, and in the erection of central stations for the supply of electricity within the districts which had been allotted to them by the legislature. They must, however, look upon that period as one wherein the foundation of all their future success had been firmly laid, and he thought they would share with him the conviction that that success was assured when they considered the large and important orders they had been called upon to supply, and the enormous demand for lights on every side. As showing the importance of their area, he might state that, putting aside the large number of non-residents who were employed in those districts during business hours, there was a resident population of between two and three hundred thousand. He had also been informed that the gas consumed in that area represented an income of £337,500 per annum, and granting that they took from the gas companies a small portion of the lighting, they would see they had every reason to anticipate a large income. From what had been stated they might look upon the last year as preparatory. It was nevertheless satisfactory to state that during the short period of that year they had earned the sum of £6,127. That amount had chiefly been obtained from the supply of light at Whitehall station. They had thought it more prudent to apply that sum towards the reduction of the general expenditure of the year, so that they might be able to start the present financial year with a comparatively clean sheet. Practically the entire expenditure of the past year had been capital expended, and he wished therefore to feel the full benefit of the now productive power of those stations which were completed. Full reference was made in the report to their Parliamentary history. They would have read that the Board of Trade, acting under the powers conferred upon them by Parliament, decided to hold an enquiry into the various provisional orders and licenses applied for by the Metropolitan Electric Supply and other companies. The inquiry, conducted by Major Marindin, lasted through the month of April. In all respects it formed a most important epoch in the history of electric lighting enterprise. A vast amount of evidence had been given by all parties concerned, and the different systems proposed for adoption had been exhaustively discussed. In the evidence given by him, the speaker, he had stated that he should not consider their company a great success until they had quadrupled their present capital. He was still of that opinion. He had told them that the total amount of capital embarked in the supply of electricity to London amounted to 3 millions, whereas the capital of the Metropolitan Gas Companies amounted to upwards of 13¼ millions, and he did not think he could be accused of exaggeration. The result of the Board of Trade inquiry had been to recommend Parliament to grant the Metropolitan Electric Supply Company rights in the areas mentioned in the report, and coloured red in the map attached to the report. Those areas practically included the whole of the theatres, and many of the most important restaurants and public halls and buildings, especially in Oxford Street, Holborn and the Strand. The offices in Chancery Lane, Lincoln's Inn and elsewhere, and the valuable residential district of Bloomsbury, were among the best parts of London, and would give them ample scope for their work. Moreover, it was satisfactory to note that, to avoid the public inconvenience of practically breaking up streets, the Board of Trade had laid down the principle of recommending for admission two companies using different systems into one area. If that principle was adhered to, future competition would be limited in extent to, he thought, the advantage of themselves and of the public. At present they had only competition in a very small degree in St. Martin's district, which did not, of course, affect them in any way. There were, however, two or three small companies who were supplying a certain amount of light in portions of the area of the Metropolitan Electric Supply. He had remonstrated with the authorities as to the fairness of such competition, and he hoped to be able to obtain the protection which was due to them, as the authorised undertakers, from those who had practically no right to supply those districts. The fact was that very few bills were perfect at first, and the flaws they had found in theirs the Board of Trade would not hesitate to alter. They would, he was sure, understand that during the proceedings before the Board of Trade, and until the recommendations had been confirmed, they had not felt justified, even had time permitted, in their completing their system. They had, however, not lost much time. Next they made arrangements for their installations, and, so far, they had saved a very considerable amount of time. As an instance of the uncertainty of their position during that period, he might mention the Eccleston Place property, to which reference had been made in the report, was purchased in February last, before the enquiry commenced, for the purpose of supplying light in St. George's, Hanover Square and St. James's. Owing to the decision of the Board of Trade, they had not been able to utilise that site; but he might state that they were in treaty for its disposal, and hoped to effect a remunerative re-sale. The Royal assent had been given to their Acts on the 2nd September last, and less than a month before the period under review. Since that time they had authority to lay down mains and complete their system, and they had lost no time in making use of their privileges. They had had only a couple of months to work in, and all their difficulties lay in the view which the Board of Trade had taken, viz., that it was desirable to hold an enquiry into the systems of certain companies who could show they had capital. He might say they were one of the leading companies, and they would see from the map the area they had now to work upon. Regarding their present position and prospects, in the first place, he would like to speak about the stations which had been erected and were being worked. First there was Whitehall station. He had stated on a former occasion that they had been making arrangements to light some large hotels in the neighbourhood of that station. One of them, the Hotel Victoria, they had been lighting ever since. Regarding the others, the "Grand" and the Metropole, the lighting of which they then considered they had practically arranged for, they had been offered a bargain which they had not felt justified in accepting. Their reason had been simply that it represented a small portion of their area, and one of the smallest installations they had, and if they had accepted the price at that particular time it would have compromised their other stations which were to be established. They had therefore declined the offer of those hotels, but he believed that the installations established in those hotels would eventually be disposed of and the light taken from the larger installations. In the Whitehall station, besides the Hotel Victoria, they had other hotels which they had been lighting for some time past, and also a number of shops and places like St. Martin's Church, Vestry Hall, the Garrick Theatre, and the huge block of buildings known as Whitehall Hall. When those places were fully lighted, and they were now fast approaching completion, they would absorb the whole of the surplus light of the station. The installation for the station at Sardinia Street, Lincoln's-Inn-Fields, was furnished and erected by the Westinghouse Electric Company, and the shareholders would be pleased to hear that the machinery had fulfilled all requirements, and had been working most satisfactorily; and there had been no hitch or failure in the supply of light to that or any other of the buildings they had supplied. They had taken on a total of 7,000 lights since the date of the opening, and he thought they would agree with him that that was not bad work for 18 weeks, considering that the cables had all to be run underground. Among the buildings they were now supplying from that station were the Gaiety Theatre, Holborn Restaurant, the Royal College of Surgeons, Exeter Hall, and many offices. In addition to this, they were under contract to supply a further 5,000 lights by the end of the year to Drury Lane Theatre, the Government Record Office, Hansard's Publishing Union, Messrs. W. H. Smith's offices, Terry's Theatre, and various hotels, offices and private residences. When all these lights had been taken it might be considered that the output of the station was fully occupied. They had, therefore, determined to increase the capacity of the station by considerably more than double, which could be done without further extension of buildings, which were arranged for a 50,000-light installation, and as they held contracts for at least 6,000 lights, he had no hesitation in saying that this second installation would be fully taken up before its completion. He would now refer to the Rathbone Place station. The board determined in February last to purchase a small station on this site as a going concern, but as the existing plant was small, and the demand for light in the district very large, they accepted a tender of Messrs. Elwell Parker, now the Electric Construction Corporation, for the erection of a powerful alternate-current plant. The first portion of that plant had now commenced running, and its light-giving capacity was fully taken up. As soon as the plant was all at work—and they hoped this would be early in March—they had in their possession contracts which would charge it to its full capacity, so that here again they would be earning a maximum revenue as soon as the station could be got to run. With regard to South Mews station, which was to supply the western division of Marylebone, they had acquired a fine site behind Manchester Square, the buildings on which were now nearly completed, and were practically ready to receive the machinery. The Electric Construction Corporation were supplying the plant for that station, and they were assured that it would be completed in April next. He was happy to state that there again they looked forward to the best results, as no less than 50 per cent. of the gross output had already been applied for. As regarded the Waterloo Wharf, they had accepted a tender from Messrs. Johnson and Phillips to erect an alternative-current station on their site at Waterloo Wharf. Owing to negotiations with the London County Council they had not yet commenced to erect buildings, but the machinery was in a forward state. They were also about to erect a station in the Strand district, and, if they obtained the necessary powers, they would erect stations to supply Paddington and the western portion of the City area. They were also considering the advisability of erecting a separate station to supply Bloomsbury and Holborn, in view of the fact that the Sardinia Street station would prove inadequate for the requirements of these districts. It must be remembered that the erection of these stations involved also the laying down of the necessary mains, and that this was by no means the least arduous part of their undertaking. They had already laid four miles of underground mains from Sardinia Street, with very successful results, and they would have eventually a complete network of underground mains traversing the whole of their districts. As, however, a considerable time must elapse before this work could be satisfactorily completed, and as it was impossible now to run any new overhead mains, the directors had succeeded in coming to an arrangement with the London Electric Supply Corporation, whereby that company had agreed on reasonable terms to hand over their existing overhead cables in the districts allotted to this company, but previously supplied by them, thus immediately enabling them to obtain a large revenue. They would probably wish to know something about their present and future revenue. Their manager, Mr. Claremont, had reported that they were at present supplying about 15,000 lights from Whitehall, Sardinia Street, and Rathbone Place, and that he estimated that that would produce a revenue of about £20,000 a year. He also stated that it would be almost immediately increased to about 30,000 lights with an estimated revenue of over £30,000 a year. When the second installation at Sardinia Street was furnished, the Rathbone Place station fully equipped, and the Manchester Square station opened, they would be in a position to supply from those four stations, allowing for a reserve of spare power 73,980 lights, with an estimated revenue of £89,250. As to the figures he had quoted, they must be taken as approximate, because they were dealing with a new business, and it was extremely difficult to get absolutely reliable estimates, but he thought he could safely say that when their present capital of £500,000 was fully employed they would be supplying not less than 100,000 lights, and that their revenue would be at least £100,000 per annum. He believed that by the spring they would have not only the whole of the capital engaged, but the whole of the installations he had indicated at work, and producing very satisfactory results. In the autumn Mr. Edison paid him a visit and went over the whole of the company's installations, and his observation was that the board were applying the science of electricity in a thoroughly practical way, and that they were doing that which could not fail to be a success. Mr. Edison had said that of all the cities in the world that he knew of there was no city so well suited for electric lighting as London, where they had large areas of great and comparatively rich populations, and at the same time the worst weather that was to be found in the world, and that electricity would become positively a necessity in London more than in any other city. He had received a telegram that morning from Mr. Edison, in which he said that 60 electric lighting companies in America were paying from 6 to 20 per cent. They were now, the chairman said, entering upon a new departure with a considerable amount of energy, and he considered it would be a grave reflection upon the directors and upon the scientific and practical men in London, if they could not do their work as well as it was done in other countries. He had the strongest possible belief that they were entering upon a successful career, and that their property, as a lighting property, would develop in as great a degree as gas had done. Therefore, with all confidence, he said that they had a great thing in hand. If people told them that this was a flash in the pan they must not believe it. He advised them to stick to their shares, and in the meantime they would find that they had a wonderfully good and promising investment. Some of his friends had told him that they had been advised that the thing could not go on, and that there was no dividend this year. It was impossible to create and erect installations of that kind, and have them all running and earning dividends, before the works were thoroughly established. They must have time to establish works, and their works were now in such a position that they would very shortly be producing very largely. At the same time, he had shown them that they could not even now produce enough for the demand. He had received a telegram that morning from Berlin—a city which was very well and satisfactorily lighted—which stated that the company in Berlin was paying 9 per cent. per annum, and that they expected a very large increase upon that, as they were now getting their stations into full occupation. Electricity had become a great power and great benefactor, and they would find from Lord Salisbury's speech the other day that it was probably the greatest factor in human progress in his time. When the board took up this question of lighting they did so from a conviction that the time had come to do it. A great deal of money had been spent in speculative purposes, and a great deal of excitement was caused. That had passed away, and in its place they had solid work. They were now getting real value for their money. After reading a telegram he had received that morning from Sir George Elliot, expressing his regret for his absence, and his belief in the prospects and solidity of the company, the Chairman said he held the strongest opinion that they were on the right road, and they were determined to pursue it with energy, and he hoped that when he had the pleasure of meeting them again they would bear in mind the remarks he had made that day. It would take some time to complete the works now contracted for, and to fully expend the money which had been subscribed. As soon as they required money they intended to put out a certain amount of debentures. He believed that they would be able to get debentures at a low rate of interest, and if this was done it would be of enormous benefit to the shareholders. However, in the event of their requiring more capital, they would come to the shareholders first and give them the advantage of taking up new shares. In conclusion, he said that he believed the property would become a very important one, and that those who held on to their shares would reap their reward in the way he had indicated. He then moved: "That the report of the directors and the statement of accounts to September 30th, 1889, submitted to the meeting, be received and adopted."

Sir R. N. Fowler seconded the motion.

Mr. Giles said that the statement made by the chairman of the progress of the company was very satisfactory. He suggested the advisability of issuing the unissued shares now that they stood at a premium.

Mr. Henderson asked if the company had any overhead wires; also whether the shareholders would have an opportunity of paying up in full the balance due on their shares.

The Chairman, in reply, said: As to making further calls, they wanted to be popular with the shareholders, and did not want to unduly depress the capital by calling up more money. As to overhead wires, the Government had laid down a law that overhead wires were to be dispensed with two years hence. The company were laying their wires underground, but they had bought from the London company a certain amount of their overhead wires, and that had been a very good bargain. He did not know that these overhead wires would be taken down in three years, but in the meantime they would be earning money by them. In the future their accounts had to be made up to December 31st in each year. When they dealt with those accounts they would also deal with the question of finance, and then they would intimate whether the shares might be paid up in advance or not.

The report and accounts were then unanimously adopted.

The retiring auditors (Messrs. Deloitte, Dever, Griffiths & Co.), were reappointed, and

On the motion of Mr. Giles, a vote of thanks was accorded to the chairman and directors, and the chairman having replied, the proceedings terminated.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The traffic receipts for the week ending December 13th, 1889, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company Limited, were £4,948.

ON THE HEATING OF CONDUCTORS BY ELECTRIC CURRENTS.

By A. E. KENNELLY.

III.

On the Heating of Bare Copper Wires and Strips Suspended in Air within Doors.

IT has been shown by Prof. Forbes and others that for bare cylindrical wires suspended in air, the temperature elevation produced in them by a current will be proportional directly to the square of the current and inversely to the cube of the diameter, provided that the loss of energy per unit surface of wire per second, known as the emissivity, be itself directly proportional to the temperature elevation. This assumption, though frequently made, is recognised to be untrue, and consequently this law cannot apply rigorously to suspended bare wires, just as it has been shown to be only approximately true for empanelled wires. Experiment shows that the emissivity rises rapidly with the rise of temperature, being in some cases nearly twice as great per degree Centigrade at 100° as it is at 20° Centigrade of temperature elevation.

Hitherto in calculating the limiting temperature of a bare wire suspended in air the emissivity has been generally taken from the data supplied by the careful experiments of Messrs. McFarlane and Nichols, who observed the rate of cooling of large metal spheres in special inclosures, conditions which are not fairly applicable to the cooling of wires, and which cannot, as Prof. Forbes himself pointed out, be strictly depended upon for that purpose.

He suggested that the effect of convection was not proportional to the surface, while radiation was; and experiments have verified this belief. Thus the emissivity for a polished copper surface in the experiments of MacFarlane and Nichols was about 0·000168 therm per degree Centigrade between 0° and 60° Centigrade. With this value Forbes and others have been led to greatly under-estimate the carrying capacity of bare suspended wires. In the table accompanying his paper already mentioned, the calculated currents to raise the temperature of bright copper wires of 0·040 inch and 0·120 inch diameter 49° Centigrade are 6·5 and 33·5 ampères, respectively; while experiment shows that about twice as much current is needed in each case. In fact, the emissivity per degree Centigrade has been found to vary from 0·00019 therm, with a thin flat bright copper strip to 0·001364 therm with a bright copper wire 0·0356 inch (0·0904) centimetre) diameter, at about 50° Centigrade temperature elevation, or in the latter case some eight times as great an emissivity as that quoted from the previous data.

A hot wire suspended in air parts with its heat both by convection and radiation. These two processes are essentially distinct, and are governed by different laws, so that the complete treatment of the subject can only be attained by dealing with each separately and summing their effects. The experiments to be described have succeeded in determining up to temperature elevations of 100° Centigrade the separate rates of convection and radiation, together with the conditions to which they are independently subject. It is true that to determine all these conditions accurately would demand much further investigation, but the results appear to be at least reliable as a good first approximation.

Instead of dealing with the emissivity in therms, as has been customary, it will be more simple and direct to give all the results in watts.

Fig. 6 represents the temperature elevation measured with different current strengths passing through uninsulated copper conductors suspended in air within doors. Five different conductors were tested, and of these four were copper wires of diameters from 0·0356 inch (0·0904 cm.) to 0·1345 inch (0·341 cm.). The fifth was a strip of bright brush copper, 1 inch (2·54 cms.) wide and 0·0065 inch (0·0165 cm.) thick. Curves I., II., III., IV., V., VI., and VII. are the traces of the observations made upon them. Their surfaces were all

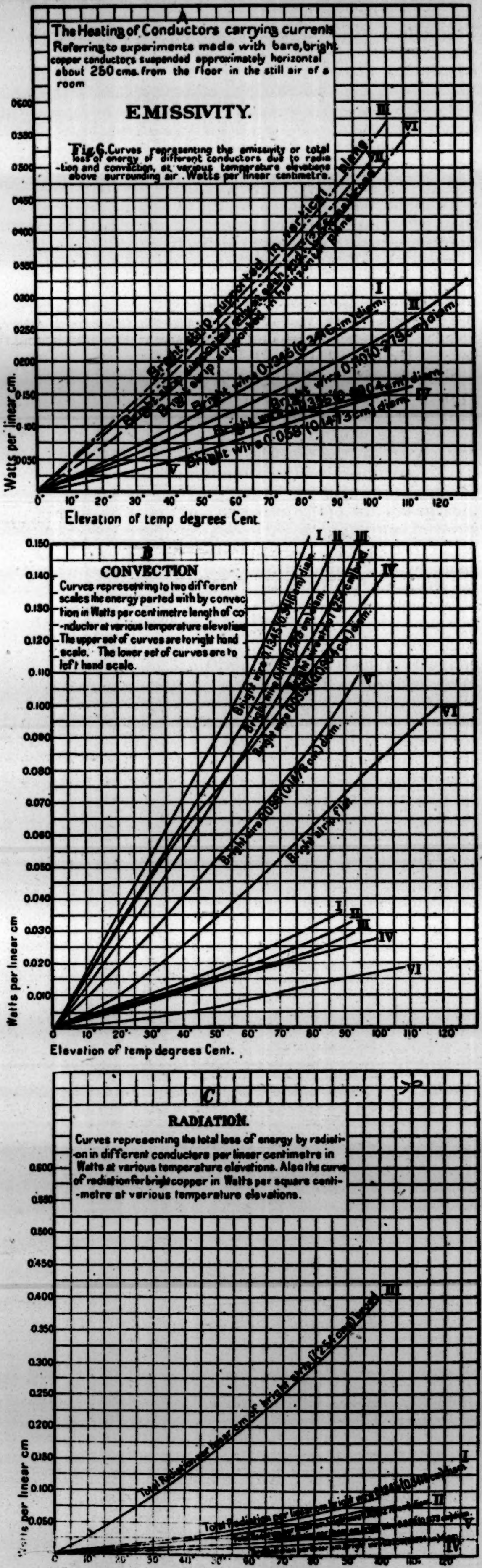


FIG. 6.

brightened with fine emery paper, except that of the strip, which needed no polishing. The wires were suspended about 8 feet (250 cms.) above the floor, between opposite walls of the laboratory, in the still air with the windows closed. These precautions were taken because it was found that a comparatively small disturbance of the air exercised a decided cooling influence on the wire. Thus a fan gently waved beneath and at right angles to one of these 25-foot lengths of wire under test produced a diminution in its resistance that was plainly discernible, and arrangements were therefore made to keep the air as free from disturbance as possible. For the same reason all the observations, though they reached their practical maxima much more quickly than had been the case with the paneled wires, were more variable and never remained quite steady. The readings had consequently to be repeated several times and means taken to obtain fair results.

The emissivity of the strip (in its upright position, to be later described) proved to be 0·24 watt per linear centimetre, at 50° Cent. temperature elevation, its surface per centimetre being 5·11 sq. cms., while the emissivity of the smallest wire was 0·08 watts per linear centimetre at the same temperature elevation, its surface per centimetre being 0·284 sq. cms. Both these measurements being referred to the unit surface instead of unit length, give, respectively, 0·047 and 0·28 watts per sq. cm., thus making the emissivity of the small wire about six times as great as that of the strip for the same temperature elevation. From this great discrepancy it appeared probable that the convection, instead of being proportional to the surface, like radiation, was equal in both cases, or nearly so; for if the convection had been proportional to the surface the mere difference in the form of the two conductors, whose surfaces were of similar appearance, could hardly account for so large a discrepancy. By assuming the convection to be equal for both wire and strip a pair of simultaneous equations was supplied by each pair of corresponding elevation points in the observation curves, thus giving radiation and convection independently for each such pair. The results for the radiation obtained in this way are:—

Radiation for both wire and strip—

	Watts per sq. cm.
At 10 deg. C. temperature elevation	0·004765
,, 20 ,, ,, ,, ...	0·01057
,, 30 ,, ,, ,, ...	0·01720
,, 40 ,, ,, ,, ...	0·02466
,, 50 ,, ,, ,, ...	0·03312
,, 60 ,, ,, ,, ...	0·04103
,, 70 ,, ,, ,, ...	0·04995
,, 80 ,, ,, ,, ...	0·05927
,, 90 ,, ,, ,, ...	0·06796
,, 100 ,, ,, ,, ...	0·07790

a rate of increase considerably beyond arithmetical progression. The test of the accuracy of the assumption on which these figures are obtained must be the accordance of this series with the laws of radiation as they are independently known.

MM. Dulong and Petit have published in the seventh volume of the *Annales de Chimie et de Physique*, 1817, a veritable poem in physical investigation upon the laws of cooling bodies. In their experiments the radiation was found to vary with the temperature elevation in geometrical progression expressed by the equation:

$$h = c(1{\cdot}0077)^{\theta}\left\{ (1{\cdot}0077)^{t} - 1 \right\};$$

where h is the quantity of heat lost by radiation from a hot body per square centimetre per second; c, a constant depending on the nature of the radiating surfaces; θ, the temperature of surrounding bodies, and t the temperature elevation of the hot body in degrees Centigrade.

Taking this formula as representing the best existing knowledge of the rate of radiation with temperature, the test of the above assumption is in the accordance of the above series of calculated radiations with a similar series obtained from Dulong & Petit's equation, making t successively 10, 20, 30, &c., up to 100. The numbers so arrived at are:

$1{\cdot}0077^{10} - 1 = 0{\cdot}0797$
$1{\cdot}0077^{20} - 1 = 0{\cdot}1658$
$1{\cdot}0077^{30} - 1 = 0{\cdot}2587$
$1{\cdot}0077^{40} - 1 = 0{\cdot}3591$
$1{\cdot}0077^{50} - 1 = 0{\cdot}4675$
$1{\cdot}0077^{60} - 1 = 0{\cdot}5844$
$1{\cdot}0077^{70} - 1 = 0{\cdot}7108$
$1{\cdot}0077^{80} - 1 = 0{\cdot}8471$
$1{\cdot}0077^{90} - 1 = 0{\cdot}9944$
$1{\cdot}0077^{100} - 1 = 1{\cdot}1534$

To test the degree of accordance between the two series, the fourth element, corresponding to forty degrees Cent. (that being probably the most favourably situated for accuracy in observation), may be multiplied by 0·06866 to make it coincide with the calculated radiation 0·02466, and all the terms of the latter series may be similarly multiplied by the same factor. We then obtain the results given in the following table.

Temp. Elevation.	Dulong and Petit's series.	Factor of comparison.	Dulong and Petit's series referred to 40° C. elevation.	Calculated series from wire and strip.	Discrepancy.
10°	0·0797	0·06866	0·05473	0·04765	0—·0007
20°	0·1658	....	0·01138	0·01057	—0·0008
30°	0·2587	....	0·01776	0·01720	—0·0006
40°	0·3591	....	0·02466	0·02466	Standard
50°	0·4675	....	0·03210	0·03212	+0·00002 minimum
60°	0·5844	....	0·04013	0·04103	+0·0009
70°	0·7108	....	0·04881	0·04995	+0·0011
80°	0·8471	....	0·05817	0·05927	+0·0011
90°	0·9944	....	0·06827	0·06796	—0·0003
100°	1·1534	....	0·07919	0·07790	—0·0013 maximum

This agreement must be considered very satisfactory, and it is difficult to suppose it merely coincidental. It not only strengthens the reliance to be placed on Dulong and Petit's law, but it also amounts to a demonstration that the convection does not depend upon the surface, or that at least it can only do so in a very limited degree.

The radiation in watts per square centimetre from a surface of bright copper may therefore be accepted as $0{\cdot}0687\,(1{\cdot}0077^{t} - 1)$ under the condition of these experiments. But Dulong and Petit's law requires that this factor 0·0687 should itself be a function of the temperature of surrounding bodies, or, in other words, that the radiation loss from a hot wire for a given temperature elevation increases with the absolute temperature. It may therefore be assumed that

$$0{\cdot}06866 = c\,(1{\cdot}0077)^{\theta};$$

and in these experiments θ, the temperature of the surrounding air, was about 26° Centigrade, so that

$$c = \frac{0{\cdot}06866}{(1{\cdot}0077)^{26}} = 0{\cdot}05625.$$

Whence the complete expression for the radiation from a bright copper wire in watts per square centimetre is:

$$0{\cdot}05625\,(1{\cdot}0077)^{\theta}\,[(1{\cdot}0077)^{t} - 1].$$

It is to be observed, however, that this factor $(1{\cdot}0077)^{\theta}$ is a deduction only, as yet not verified by experiment. It is difficult to decide this point in the summer season, but it is hoped to determine the question of its existence experimentally during the ensuing winter by observing whether the radiation does vary to such a degree for given temperature elevations when the temperature of surrounding bodies is changed. Should this factor's existence be verified it would completely establish the application of Dulong and Petit's law. If, on the other hand, the variation is not to be detected, while it would certainly weaken the position, the general evidence, apart from Dulong and Petit's law, is sufficient to maintain the use of the term $[(1{\cdot}0077)^{t} - 1]$, while the factor 0·06866 would necessarily be regarded as independent of θ. With this reservation the retention of the factor is probably justified, especially as for most practical purposes the question is not a vital one.

The following table gives the radiation in watts per sq. centimetre of bright copper for $\theta = 25°$ Centigrade, and if the factor $(1{\cdot}0077)^{\theta}$ be found to have an ex-

TABLE OF CURRENT STRENGTHS CAPABLE OF ELEVATING THE TEMPERATURE OF BARE COPPER WIRES OF 98 PER CENT. CONDUCTIVITY SUSPENDED IN STILL AIR.

Diameter of conductor.		5 deg. C.		10 deg. C.		20 deg. C.		40 deg. C.		80 deg. C.	
Inches.	Cms.	Bright.	Blackened.	Bright.	Blackened.	Bright.	Blackened.	Bright.	Blackened.	Bright.	Blackened.
0·05	...	7	8	12	13	15	16	22	23	28	31
0·10	...	17	18	24	26	33	36	50	52	62	70
0·15	...	27	30	38	43	53	60	74	84	100	114
0·20	...	49	41	52	62	74	85	103	120	140	166
0·25	...	38	55	67	81	96	114	135	161	185	224
0·30	...	61	71	85	100	120	143	168	204	233	285
0·35	...	73	87	102	124	145	176	204	249	282	350
0·40	...	87	106	122	148	172	211	241	297	335	418
0·45	...	101	124	142	173	198	248	280	348	392	492
0·50	...	116	144	162	200	228	285	320	402	449	570
0·55	...	131	162	184	228	260	325	362	460	510	650
0·60	...	146	182	206	258	290	366	407	518	571	731
0·65	...	162	203	229	288	322	408	452	578	636	820
0·70	...	178	226	252	320	355	454	500	640	704	908
0·75	...	196	249	276	352	386	498	550	704	772	1,000
0·80	...	213	273	300	386	420	544	598	768	819	1,100
0·85	...	232	300	324	420	456	591	648	838	908	1,190
0·90	...	250	324	348	455	490	640	700	908	980	1,290
0·95	...	270	352	375	492	530	692	752	982	1,060	1,420
1·00	...	290	375	400	528	565	740	800	1,050	1,130	1,500
...	0·20	12	13	18	20	25	27	35	38	47	53
...	0·40	28	30	40	46	56	64	77	90	105	121
...	0·60	45	50	63	75	90	105	125	150	172	206
...	0·80	64	76	90	108	126	152	179	217	247	305
...	1·00	85	104	120	147	169	207	236	290	329	410
...	1·20	108	133	150	184	212	264	298	372	416	526
...	1·40	132	163	184	230	261	328	364	461	512	652
...	1·60	156	190	220	276	310	392	415	553	610	785
...	1·80	180	230	256	326	360	462	510	650	715	924
...	2·00	201	267	293	377	413	532	583	750	819	1,070
...	2·20	237	308	330	430	465	605	662	858	928	1,220
...	2·40	268	348	372	486	524	685	746	970	1,050	1,380

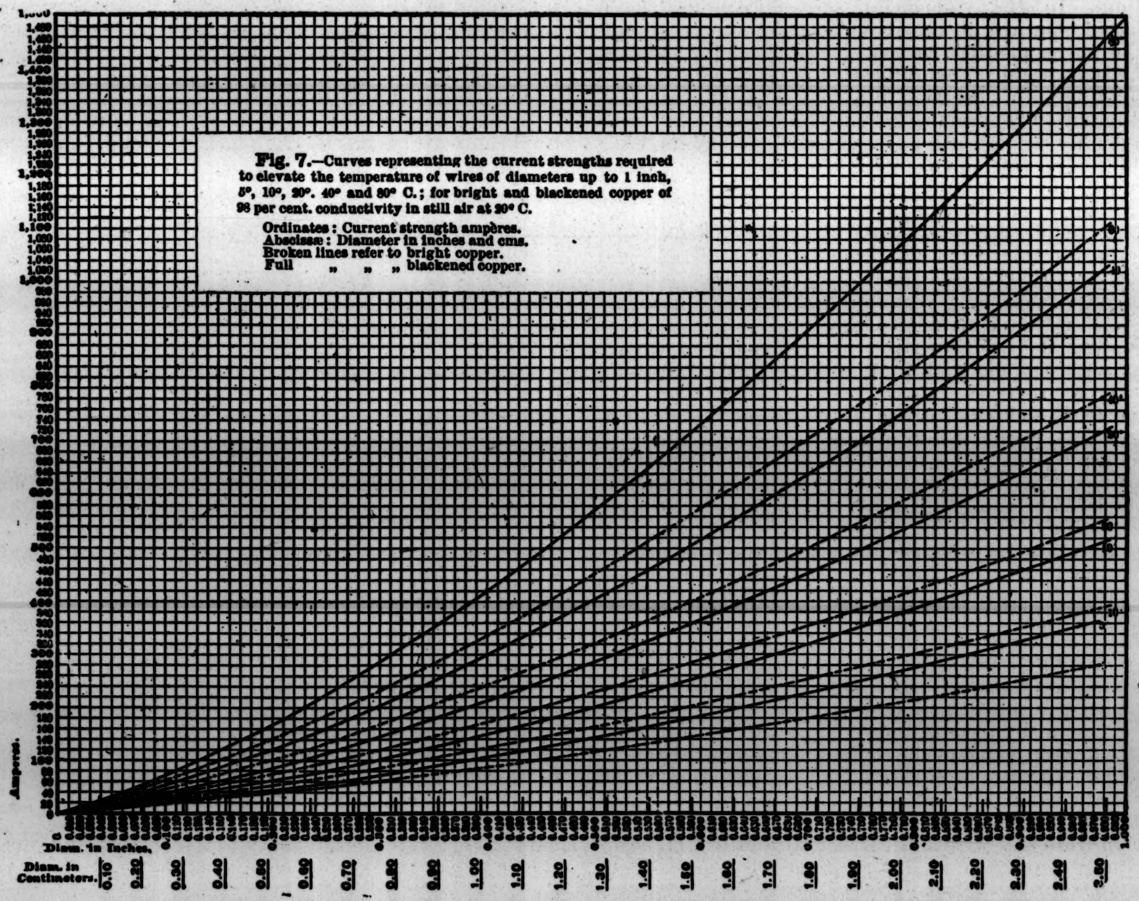


Fig. 7.—Curves representing the current strengths required to elevate the temperature of wires of diameters up to 1 inch, 5°, 10°, 20°. 40° and 80° C.; for bright and blackened copper of 98 per cent. conductivity in still air at 20° C.

Ordinates: Current strength ampères.
Abscissæ: Diameter in inches and cms.
Broken lines refer to bright copper.
Full „ „ „ blackened copper.

FIG. 7.

perimental existence, it will be a simple matter to amplify the table for various values of θ from zero to 30° Centigrade.

RADIATION TABLE IN WATTS PER SQUARE CENTIMETRE FOR BRIGHT COPPER.

Temper. Elevation. Degree Cent.	$(1{\cdot}0077^t-1.)$	Radiation.
5°	0·0391,	0·002665
10°	0·0797	0·00543
15°	0·1219	0·00831
20°	0·1658	0·0113
25°	0·2114	0·0144
30°	0·2587	0·0176
35°	0·3080	0 0210
40°	0 3591	0·0245
45°	0·4123	0·0281
50°	0·4675	0·0319
55°	0·5249	0·0358
60°	0·5844	0·0398
65°	0·6464	0·0441
70°	0·7108	0·0484
75°	0·7777	0·0530
80°	0·8471	0·0577
85°	0·9194	0·0627
90°	0·9944	0·0678
95°	1·0724	0·0731
100°	1·1534	0·0786

The radiation is thus roughly 0·0006 watt or 0·00014 therm per square centimetre per degree Centigrade, increasing in geometrical ratio; and one square metre of bright copper at 100° Centigrade elevation would radiate about 800 watts.

The same series of simultaneous equations which gave the radiation values furnish also the convection for wire and strip and its rate of change. Fig. 6 gives the result of the analysis. Curves Nos. I., II., IV. and V., in the left-hand section (A) represent the total emission in watts per linear centimetre as actually measured, and as composed of both radiation and convection. In the right-hand section (C) the total radiation obtained in the above manner is represented in the corresponding curves I., II., IV. and V., drawn to the same scale. The difference at each pair of corresponding points between the total emission and the total radiation represents the convection loss, and this is given by the lower set of curves, I., II., IV. and V., in the central section (B) to the same scale, and also in the upper curves to this scale magnified five times for the benefit of clearer comparison. It will be observed that the convection was nearly the same in each case, the effect of increasing the diameter of the wire from 0·0356 inch (0·0904 centimetre) to 0·1345 inch (0 3476 centimetre), that is, nearly four times, only appearing to increase the convection 20 per cent.; thus corroborating the results arrived at by the test of agreement with Dulong and Petit's law. The convection appears to increase rather more rapidly than the temperature elevation, except in the case of the smallest wire. This result is not in accordance with those of Dulong and Petit, who found the convection in their experiments with cooling spheres to increase as the power 1·233 of the temperature elevation, or according to the factor $t^{1\cdot233}$. It is quite possible, however, that the convection for spheres may not be the counterpart of that for long wires, and it is to be observed that not only are the laws of convection a branch of hydrodynamics more complex than those of radiation, which does not appear to vary with the form of surface, but the number and precision of these particular experiments scarcely warrant any more definite deductions to be made in this direction.

For practical purposes, therefore, it will be sufficient to take a mean value of the convection, and to assume it to be proportional to the temperature elevation, until further investigation may afford more precise information. We may, therefore, take the loss of heat by convection from any wire at the mean value of 0·00175 watt per linear centimetre in still air for each degree Cent. of temperature elevation; that is, 1 kilowatt for every 114 metres at 50° Cent. temperature rise.

Fig. 6 (*a*) also shows that the total emission of a wire per centimetre may rise faster or slower than the temperature elevation, or may even trace a straight line proportional to the elevation for a certain distance, according to the dimensions of the wire and the relative proportions of convection and radiation in its cooling. The smaller the wire the greater the likelihood appears to be of the rate of emission falling behind the rate of rise in temperature.

Experiments were next made to determine the amount of variation that a difference in quality of of surface could effect in the rate of radiation. For this purpose five wires of the same dimensions and material—that is to say, five lengths of the same wire—were suspended parallel and their surfaces coated with different substances. On another occasion five lengths of the same strip were treated and experimented upon in a similar manner. The results showed that in still air a black coating of sulphide of copper, produced by painting the bright surface with a solution of sulphide of sodium, reduced the temperature elevation corresponding to any given current nearly 30 per cent. both for wires and strips; while a coating of lampblack and shellac (dead black carpenter's varnish) similarly reduced the temperature of the strips nearly 50 per cent. This has a useful bearing upon bare copper conductors within doors, say in an illuminating central station, for if their surfaces are so large that the heat loss takes place principally by radiation (and for surfaces above 5 square centimetres per linear centimetre convection plays but a small part), the saving of energy produced by painting the conductors with this varnish will, through the lowered temperature and resistance, amount to $\frac{t}{6}$ per cent., where t is the previous temperature elevation. So that if these conductors be maintained at 50 degrees Centigrade elevation in the bright state this will fall to about 27 degrees Centigrade after painting, with a resultant saving of about 8 per cent. of the whole energy previously generated by the current in the painted length. This applies not only to bright copper, but also to copper that has become slightly tarnished by age, but may not apply equally to copper whose surface is encrusted with dust or smoke.

By first determining the radiation and convection for the bright wire and strip, then assuming the convection to be equal for the other coated wires and strips, respectively, the mean ratio of the radiation from each quality of surface to the radiation of bright copper was calculated to be as follows:

For the wires:

Thin coating of brown shellac varnish, 1·6; thick coating of copper sulphide (CuS), 2·3; thick coating of lampblack made adherent by molasses, 2·0.

For the strips:

Thick coating of brown shellac varnish, 1·8; rather imperfect and thin coating of copper sulphide, 1·5; lampblack by deposit from smoky candle, 1·4; thin coating of varnish, lampblack and shellac, 2·0.

The coating of copper sulphide was not so successful in promoting radiation with the strips as with the wires, partly owing, however, to imperfect coating. The necessity for a compact adherent layer in obtaining active radiation is also shown, for while lampblack, deposited from a flame, only added 42 per cent. to bright radiation, lampblack applied with thin shellac varnish doubled it.

We may therefore take the radiation from a properly blackened wire as double that from a bright wire.

Experiments were also made with two strips of bright copper to ascertain how far their convection was affected by their plane of suspension. In the above-mentioned tests of strips, they were all secured at their extremities to lie flat; but toward their centre they each dipped to one side or the other out of the horizontal plane, making a dip of about 45°, and the following tests were made to determine whether the convection depended to any extent upon this angle:

These two strips were supported in air at about every three feet, one of them being fixed in the vertical plane, while the other rested flat above all the supports. Their perpendicular distance apart was eight inches (21 centimetres). The testing current was sent through them in series, and the temperature elevations determined for each in the usual way. Curves III. and VI., fig. 6 (*a*) represents their relative behaviour. In the first trial the temperature elevation of the flat strip reached 120° Centigrade, at 101 ampères, while that of the upright was only 102·5° C. To make certain that this difference was not due to any inequality of radiating power, the strips were exchanged in position, the upright one being now flat, and *vice versâ*. On repeating the test, the temperature elevation of the flat strip reached 130° C. at 100 ampères, while that of the upright strip was 101·3° C., practically the same result, and the only means of accounting for the difference was the plane of the strips. The diagram shows that the emission of the upright strip was greater than that obtained from it in the previous test while unsupported and drooping, and the emission from the flat strip less—a result quite in accordance with expectation.

Fig. 6 (B) gives the calculated values of the convection from the upright and flat strip. The latter is seen to be about 45 per cent. less than the former, a rather surprising difference, for it would indicate that, supposing the upper surface of the flat strip to be equally affected by convection to the same degree as one side of the upright strip, the convection from the lower surface would then be ten times less.

The final results of the experiments on bare wires in still air point to the following means of calculating the current strength necessary to raise any given copper wire to a certain temperature elevation :

Let d be its diameter in centimetres ;
t „ the given temperature elevation ;
r „ its resistivity at 0° C., in ohms ;
θ „ the temperature of surrounding objects ;
m „ the coefficient of surface for radiation.

Let $t + \theta = \mathrm{T}$, the temperature attained by the wire. Then its resistance per centimetre will be :

$$\frac{4\,r\,(1 + 0{\cdot}00388\ \mathrm{T})}{\pi\,d^2}\ \text{ohms.}$$

The energy developed per centimetre by a current of c ampères will be :

$$\frac{4\,c^2\,r\,(1 + 0{\cdot}00388\ \mathrm{T})}{\pi\,d^2}\ \text{watts per centimetre.}$$

The heat convected from it will be : $0{\cdot}00175\ t$ watts per centimetre.

The heat radiated from it will be :

$$d\,m\,\pi \times 0{\cdot}0687\ [(1{\cdot}0077)^t - 1]\ \text{watts per centimetre.}$$

Or if the radiation for t deg. elevation be taken from the previous table and denoted by R_t :

The total radiation per linear centimetre $= d\,m\,\pi\,\mathrm{R}_t$ Watt. Equating the gain and losses,

$$\frac{4\,c^2\,r\,(1 + 0{\cdot}00388\ \mathrm{T})}{\pi\,d^2} = 0{\cdot}00175\ t + d\,m\,\pi\,\mathrm{R}_t\,;$$

$$\text{whence,}\qquad c = 0{\cdot}886\ d\sqrt{\frac{d\,m\,\pi\,\mathrm{R}_t + 0{\cdot}00175\ t}{r\,(1 + 0{\cdot}00388\ \mathrm{T})}}$$

for copper of 98 per cent. conductivity $r = 1{\cdot}65 \times 10^{-6}$; so that simplifying—

For bright wires :

$$m = 1,\ c = 28{\cdot}9\ d\sqrt{\frac{5{\cdot}0\ \mathrm{Q}\,\mathrm{R}_t + t}{1 + 0{\cdot}00388\ \mathrm{T}}}\,;$$

for blackened wires :

$$m = 2,\ c = 28{\cdot}9\ d\sqrt{\frac{1140\ \mathrm{Q}\,\mathrm{R}_t + t}{1 + 0{\cdot}00388\ \mathrm{T}}}\,;$$

where $\mathrm{Q} = \pi\,d$, the circumference of the wire.

The following table of current strengths capable of elevating the temperature of bare copper wires of 98 per cent. conductivity suspended in still air, 5 degrees, 10 degrees, 20 degrees, 40 degrees and 80 degrees, above surrounding air and objects at 20 degrees Centigrade, has been calculated for bright and blackened wires by the use of these formulæ. It will be observed that the currents are given up to 1,500 ampères, while 100 ampères was the experimental limit to which this series was carried. To present, however, a comparison of the results calculated in the table with those actually measured up to that limit, the following may be noticed :

For elevation of

5° C.,	the *observed* current was	24	ampères ;	*tabulated*,	24
10° C.,	„ „	34·5	„	„	34
20° C.,	„ „	47·5	„	„	47·5
40° C.,	„ „	67	„	„	66
80° C.,	„ „	92	„	„	91

Fig. 7 gives the above table in graphic form, the continuous lines representing bright, and the broken lines blackened, wires.

TESTS MADE FOR HEALTH DEPARTMENT OF THE CITY OF NEW YORK.

IN accordance with the statement made in our last issue we here give the tests which has been forwarded to us by Mr. Harold P. Brown.

"*October 15th, 1889.*

"To the Sanitary Superintendent.

"We visited the plant of the Manhattan Electric Light Company at 80th Street and Avenue B on the 14th inst., and inspected the dynamos in operation thereat, testing the leakage of electric current from each. This station has but recently been completed, and we are informed that most of its wire is new. The following is the detailed result of our investigation :—

No. of Test.	Character of Dynamos.	Outgoing Wire.	Return Wire.
		volts.	
1	Continuous current, Jenney, ...	900	1,650
2	„ „ „ not running	...	...
3	„ „ „	none	1,020
4	„ „ Brush	„	none
5	Thomson-Houston, No. 1	300	150
6	„ „ „ 2	none	60
7	„ „ „ 3	„	30
8	Alternating current „ 1, 1,000 volts ...	450	600
9	„ „ „ 2, not running ...	...	...
10	„ „ „ 3, 1,000 volts ..	150	150
11	„ „ „ 4 „ ...	450	450
12	„ „ „ 5 „ ...	600	450
13	„ „ „ 6 „ ...	600	600
14	„ „ „ 7 „ ..	450	450
15	„ „ „ 8 „ ...	450	300
16	„ „ „ 9 „ ...	600	600
17	„ „ „ 10 „ ...	300	450

"The Cardew patent voltmeter was used for this purpose, one terminal being grounded. The instrument contained three resistance coils in series with it, so that the voltage could be read from 30 to 3,600 volts. The coils were wound so as to cancel the effect of self-induction, and the apparatus has recently been tested by two authorities and found correct within 1 volt. A third calibration is now being made.

"This leakage indicates imperfect insulation. A person touching a wire leaking at a defective point would, if a ground connection were made at the same time, receive the amount of leakage indicated in our table. It is our opinion, based upon our own experiments, and authentic records of the experiments of others, that an alternating current of 250 volts is dangerous to the life of any person through whose body such current might pass ; also that a continuous current of 700 volts is, in a like manner, an unsafe amount of electrical force to be permitted to be used upon an imperfectly insulated wire.

"We therefore respectfully recommend that proper measures be taken to reduce the electrical pressure upon wires used in the City of New York to less than what we have indicated as unsafe.

"(Signed) CYRUS EDSON, M.D., *Chief Inspector.*
EDWARD W. MARTIN, *Chemist.*

Explanation.

"Tests No. 1, No. 3, and No. 5, are upon poorly insulated circuits, which permit a portion of the continuous current to flow to the ground (it was raining a little on that evening).

"Tests No. 4, No. 6, and No. 7, are upon well insulated circuits, which keep the continuous current from leaking to any dangerous extent.

"Tests No. 8, and No. 10 to No. 17 are upon circuits having most excellent insulation and construction, four of them being in subways and the others on poles. It is said that galvanometer tests of these circuits, when the dynamos are not running, show *perfect insulation.* This is probably true, yet the 'leakage' indicated by the Health Department measurements *averages 45 per cent. af the pressure upon the conductors.*

“This is because the alternating current is used. When an electrical current is set up in any circuit, a momentary current in the opposite direction is produced in any parallel conductor, by what is called induction; when the first current is stopped an induced current is produced in the same direction as the first.

“It is therefore evident that with the alternating current, which is a series of impulses, flowing first in one direction and then in the other, a corresponding series of induced currents is produced *outside the insulation of the wire,* if any moisture is present to serve as a conductor. If the wires are contained in lead or iron pipes the metal transmits the induced current.

“*There is no insulation known to science that can prevent the mysterious action of induction,* and the distances at which it will act are almost incredible. Mr. Edison, in his railway train telegraph, has transmitted signals by induction through over 400 feet of dry air, which is an excellent insulator. This telegraph system is operated by a feeble battery current, which could not possibly inflict injury, but in the alternating system of electric lighting the pressure is at least five times as much as is required to produce death. Wires transmitting the latter current, whether on pole lines or underground, can in no way known to science be so insulated as to be safe. For instance, in Dallas, Texas, where the conductors are said to be well insulated, inclosed in pipes and placed underground, a working man named Thomas Madigan was killed on April 23rd, 1889, by touching an insulated house or secondary wire while at work in the Grand Windsor Hotel.

“The alternating current has been in extensive use for less than two years, and yet it has killed at least 40 persons. On the other hand, arc light currents have been widely used for the past 10 years. During this time the high-tension continuous current has killed but 10 persons, and the high-tension pulsating current 60. There has never been a single death caused by the low-tension continuous current which all companies are free to use.

“All arc light currents may be made safe by proper precautions, without cutting the pressure down to the limits advised, but unless some device can be invented which will guard against the effects of induction, the high-tension alternating current should be prohibited. The only reason that the deadly alternating current is used, is that the electric light companies may economise in wire at the expense of public safety.”

SOME NEW FORMS OF ELECTRICAL TREATMENT.

THE President and past-Presidents of the City and Guilds of London Institute Old Students' Association gave a very pleasant *soirée* at the Institute of Medical Electricity, Waterloo Place, S.W., on Thursday, December 19th. The proceedings commenced with a reception, and included, besides a vocal and instrumental concert and dancing, an exhibition of electrical apparatus, and of Edison's phonograph, kindly lent by Col. Gouraud. A special feature of the evening was an address, with experiments, by Mr. H. Newman Lawrence, on “Some new Forms of Electric Treatment,” which was delivered in the “electrified room.”

The lecturer said · I am afraid I can hardly speak of this address as part of the evening's amusement. Perhaps it is rather too serious a matter for the occasion; but it was thought by our committee that this would be a good opportunity for one who has been so long connected with this association to say a few words about a special work, which is to a large extent new, and has created a considerable amount of interest, especially among my friends of the electrical profession. I do not propose to enter into anything severely technical; but, just as briefly as may be, to say a few words upon a few special modes of treatment which have been practised, and are being practised and investigated in this building, under the auspices of the Institute of Medical Electricity. Most of us, no doubt, are acquainted with what they call the ordinary methods of treatment by electricity. They are generally familiar to us, though in the form of shocks, more or less unpleasant, which we have at one time or other experienced—perhaps more in fun than anything else—but still we do not like them. Another method, and, perhaps, a little better one, is what is called ordinary galvanisation, or putting the battery on. Those of you who are electricians will be able to appreciate the extreme scientific accuracy of that treatment. The ordinary methods such as we practise here are, briefly, the passing of electric currents through the different parts of the body under different conditions, careful measurements being taken in all cases. I will not stop to go into this more fully than to say that they include the use of continuous currents, alternating currents and interrupted currents. I desire more particularly to call your attention to the few new forms which we have adopted here. First of all I will speak of the apparatus known as the “electrified room.” This electrified room was invented by Captain Byng, R.N., and we have adopted it here for the very special reason that it enables us to pass electric currents—very minute perhaps—through patients without their being aware of the presence of these currents. The apparatus consists, briefly, of a metal floor insulated from the other floor, and a metal ceiling, or brass work, which is also insulated from everything else; and we charge these two by means of a large induction coil, which I will now put in action, and ask these ladies and gentlemen seated here if they can feel any evidence of electrical action. Now, the whole of this party sitting on this floor are electrified, though, I suppose, they are not aware of any sensation. If anyone does feel anything perhaps he will kindly tell us; but I very seldom find that patients feel anything. What is happening now is that the whole of the atmosphere between these two poles is under strong electric agitation by alternating currents, and all those human bodies now upon the platform are influenced by it without being aware of it. The simplest proof of that—a proof I see already put into effect—is that if anyone stands off this floor, and thereby becomes connected to earth, touches any one on the floor, a spark and a distinct shock are instantly apparent. That is a very simple proof of the fact that he is electrically influenced, at any rate; but now I should like to submit a proof of the presence of alternating currents, and if some gentleman will be kind enough to come forward in order that I may put his body to the test I shall be very much obliged.

I am going to put the electrodes upon the body of this gentleman, and attached to these electrodes is a telephone; and I will ask you when I have set the apparatus going to kindly pass the telephone round. It is connected now to the patient, as we will for the time being call him, and those of you who listen to the telephone will hear a distinct buzzing noise, which is always indicative of alternating currents in the circuit.

You will observe that all the electric effect is coming from the patient, and not from anything else. The patient feels nothing whatever of it.

There is a number of varieties of these experiments which might be carried on, showing the action in the field, even when special efforts are made to insulate the patient; but I do not propose to go through the whole series. I have just shown you that as an illustration of the way in which a patient can be influenced without being aware of it.

In addition to that, we use this room in a form combining with it “massage,” or manipulation, in such a manner that the action of manipulation takes a portion of the current or the charge from the patient through the body of the operator to the earth, so that the patient gets the advantage of the manipulation and of the electricity at the same time. This particular form of treatment has proved extremely valuable in many cases, and we have used it with great success in such cases as chronic rheumatism, paralysis, infantile paralysis, nervous prostration, and similar diseases. I am not saying what might be done with it, but only what has been done with it.

Another and a still newer form of treatment occurred to me, and I had hoped to be able to show the apparatus here; but, unfortunately, it takes up too much space. It is what I call an electro-gymnastic apparatus, and its object is to administer electrical currents of various strengths and character during the time that mechanical exercise is being carried out.

One form of my apparatus consists of a platform carrying an upright post or support terminating at the top in a lever. To one end of the lever is attached a cord connected to a weight carriage sliding on an inclined plane, while to the other end cords and handles are attached. Conductors are arranged along the uprights and part of the lever to the cords and handles. Conductors of wire gauze are also arranged upon the platform in such a manner that a patient may stand upon them and be otherwise insulated. These various conductors are connected in such a way to the poles of one or more batteries that when a patient standing upon the platform grasps the handle or handles currents of suitable strength and character may pass through his limbs or whole body, as may be required during the time that he is exercising his muscles by pulling at the weighted lever. Other forms are arranged for the passage of currents during the exercise of the legs either separately or together. It is easy to see that any number of circuits may be arranged, all including such portion of the patient's body as may be under exercise at the time.

There is a very remarkable feature connected with the use of this apparatus, and one which physiologists, so far at least as they have been asked, are unable to explain. Suppose we put the maximum current on while the patient is at rest; the moment he begins to move his muscles he finds the effect of the current diminished by at least one-half, probably more. So the result of the use of the apparatus is that we can, while exercise is going on, administer much stronger currents than while the patient is at rest; the object being to promote nutrition of muscles that are short of their proper development, and to get the advantage of the electrical nutrition, in addition to the mechanical exercise. That apparatus has been tested with a few patients only; but all who have tried it have been considerably benefitted.

There is a third form of special treatment, a new form which is due to my able colleague, Dr. Herries. Of course, *electrolysis* is not new; but this is a special form of application which Dr. Herries has instituted with very marked success. He has used various electrodes, some of which have been designed by him. They are rather unpleasant-looking instruments; but patients generally say that they do not find their action very unpleasant. Here we have a two-pointed needle, both points connected to the same pole. Here we have a flat three-pointed needle; and here we have a further development in the form of a triangular-shaped three-pointed needle, the triangle at the base being rather less than one-half the triangle at the head. The use of these needles is to surround, as far as possible, the unpleasant growths apparent in some skin diseases. Dr Herries finds that many of these skin diseases are due most emphatically to the presence of germs, and he thought it would be a very good way of destroying these germs if he could electrolysise them. These are the needles invented for this purpose, and they have been used with very satisfactory results. This three-pointed needle can be passed all round the nodule, and when the current is passed we find a complete effervescence going all round the needle points; the nodule becomes very pallid, and it is apparent that great agitation is going on beneath the surface. It would take too long to go into the matter fully—I may simply say that it has resulted in the apparent destruction of germs in several cases. In one case of that very unpleasant disease, lupus, of eight years standing, after seven sittings, Dr. Herries was able to send the patient away quite cured. Of those under treatment some have made very rapid progress, and others are progressing very satisfactorily, but some cases are so extremely chronic that we cannot expect to deal with them in the short number of sittings I mentioned.

I now wish to call your attention to an entirely new method, which is also mainly due to Dr. Herries, although he and I have worked together to carry the thing out. The name given to it is that of cataphoric medication, a word which carries its own meaning very well. It depends for its action on what is known as *cataphoresis*, or the power of electric currents to carry with them solutions of drugs through a septum. It is a form of osmosis hurried up by electricity, and we find it possible to pass through the skin by its means solutions of various drugs. We do not claim that the idea is new; it has been experimented upon in Germany with a certain amount of success, and in a small way in England without success, for the very simple reason that only one particular form of the operation was tried, and, as most of these things are tried by the medical profession, in a very haphazard way. The medical profession generally seems to suppose that electricity is a thing to be played with (by themselves), and that there is no need to learn the various electric details before they try various experiments on their patients. I am not saying this simply because you are for the most part an audience of electric folk, because I have said the same thing to an audience of medical men quite recently, and they admitted what I said to be true. Many of the most important electrical operations of the day are utterly spoiled, and then condemned, simply through want of attention to electrical details. This method of cataphoric medication I had hoped to show you by an experiment, but I found it would take too long, and I was obliged to give it up. But the experiment has been carried out here, and I will just briefly illustrate it. We had two cups, one containing a solution of sulphuric acid and the other a solution of chloride of *barium*. We then connected the two by a conductor in the form of a glass tube filled with a conducting fluid, which had no action either upon the sulphuric acid or the chloride of barium, salt and water, in fact. Then by placing the positive electrode in the solution of sulphuric acid, and the negative in the solution of barium, and passing the current through for about three-quarters of an hour, we found that some of this sulphuric acid had travelled along the conductor in sufficient quantity to throw down the *barium* in the vessel, and we got a precipitate of sulphate of barium. That was a most distinct proof that the electric current has a power of passing solutions along certain conductors. Further, we proved that it has the power of passing solutions through the skin. We tried a solution of cocaine, and we found when we passed the current from one point to another of a man's body that, after 30 minutes of 20 milli-ampères, that portions of the skin under the positive pole was thoroughly anæstheticised; so much so, that we could pass needles to a depth of a quarter of an inch, without producing any sensation of pain in the patient. We had further proof. We succeeded in passing iodide of potassium into the kidneys, and tested its presence in the urine two hours afterwards. In another case, one of rheumatic gout, the same thing was passed into a number of joints with excellent results. Solutions of mercury and other drugs have been similarly passed into various parts of the body, and we are hoping very shortly by this method to deal with such troubles as liver complaints, and possibly, lung diseases.

These few sketchy remarks may perhaps briefly, of course, indicate what an enormous field for investigation, and for good and useful work, is before us. I am glad to have had the opportunity of putting these few facts before you, because I wish my old friends of this association to see that at this Institute we not only treat patients as instructed by the doctors in the ordinary methods, but also endeavour to carry out scientific investigation, and by new developments promote good and more accurate work in electro-therapeutics.

NEW PATENTS—1889.

19748. "Improvements in apparatus connected with 'incandescent electric lamps' for the use of dentists, surgeons, and others." W. Broughton. Dated December 9.

19808. "Improvements in reflector adjusters for oil lamps, gas, or electric lights." R. F. Dewhurst. Dated December 10.

19831. "Quick make and break electric switches." C. M. Dorman and R. A. Smith. Dated December 10.

19835. Improvements in electrical signalling apparatus for the prevention of collisions between railway trains." M. Perls and T. Perls. Dated December 10.

19857. "Improvements in secondary battery elements." Sir C. S. Forbes. Dated December 10.

19861. "Improvements in secondary batteries." C. H. Logan. Dated December 10. (*Complete.*)

19875. "Improvements in electric gas-lighters and extinguishers." N. Newman. Dated December 10. (*Complete.*)

19883. "Improvements in electrical secondary batteries." J. K. Pumpelly and F. D. Thomason. Dated December 10. (*Complete.*)

19892. "Improvements in machines or apparatus for welding metal by means of electricity." H. E. Fowler. Dated December 10. (*Complete.*)

19946. "Improvements in telegraph transmitters." O. D. La Dow. Dated December 11. (*Complete.*)

19951. "Improvements in electrical switches." H. Bailey. Dated December 11.

19979. "The improvement of telephones." W. Andrews Dated December 12.

20022. "A bi-planar electric switch." E. Wilson. Dated December 12.

20050. "An improved spirit or liquid measure, self-closing and self-registering, without electricity or a float." T. M. Smiddy. Dated December 13.

20059. "Improvements in and connected with electrical safety 'cut-outs' and 'switches.' C. R. G. Smythe and E. Payne. Dated December 13.

20079. "Improvements in fittings for outside and other electric lamps or lanterns." R. H. Hughes and R. S. Hughes. Dated December 13.

20082. "A method of and apparatus for signalling numerals, letters, and other symbols by electric light." R. T. Turnbull. Dated December 13.

20163. "Improvements in propelling tricycles and other velocipedes by electricity." T. Machin. Dated December 14.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1888.

17718. "Improvements in electric cut-outs or circuit breakers." T. Parker and E. S. G. Rees. Dated December 5. 6d. Consists of an electro-magnet, an armature, a switch, and a trigger which is operated by the armature to release the switch. The coil of the electro-magnet may form part of the main circuit, or it may be included in the shunt across that part of the circuit in which the E.M.F. is generated. The armature is held away from the electro-magnet by a weight or spring sufficient to prevent the attraction of the armature into contact with or proximity to the poles of the magnet until the current reaches a certain amount. The armature is provided with a projecting part, or is otherwise constructed so that some portion of it comes into contact with and releases the trigger when the armature is attracted. The trigger is constructed and arranged to hold the switch in a position closing the circuit until the trigger is released, whereupon the switch is pulled open by a spring. The switch is closed by hand. 1 claim.

18108. "Improvements in casings for electric cut-outs." H. H. Lake. (Communicated from abroad by S. Bergmann, of New York.) Dated December 11. 6d. Consists in the combination with the body of the casing of an electric cut-out of a transparent incombustible cover. 4 claims.

18589. "Improvements relating to secondary batteries." J. L. Huber. Dated December 19. 8d. The inventor imbeds in the active mass for the storage of the electricity, such as metallic compounds or substances, conductors of electricity in the form of a grating or screen in such a manner that the active mass will form a layer all around the single bars or rods constituting the meshy or reticulated conductors, and the finished electrode will maintain the form of a network or sieve. 4 claims.

18636. "Improvements in electrical accumulators." J. C. Fuller and G. Fuller. Dated December 20. 4d. Claim:—In electrical accumulators, the employment of porous partitions between each plate of the battery or arranging each alternate plate in a porous pot, whereby the plates are separated from each other, substantially as and for the purposes described.

CORRESPONDENCE.

Edison and the Lalande Battery.

A contemporary of yours makes allusion to what evidently must be another of the misconceptions which the non-scientific Press is heir to, namely, the discovery by Mr. Edison (?), "after thousands of experiments," how to reduce the internal resistance of a battery to a minimum. The same journal makes reference to an advantage which was claimed for the Lalande battery (which Mr. Edison, from accounts, claims to have discovered) at its inception in this country, that it would not only pay all expenses, but the balance realised by the waste products would show a margin of profit. Now, when the Lalande battery was first introduced here, the form or construction was not suitable for electric lighting on anything like a practical scale; but I believe it has evolved—to use a becoming more and more favourite Darwinian expression—to something like practical dimensions, although it is a long time since I heard anything about it.

The chemical combinations, I think, are excellent; the oxide of copper next the negative in a caustic potash solution, in which on open circuit, with fairly pure zinc, the local action is very small; and yet with a closed circuit the potash is an almost unrivalled solvent and a splendid conductor. No doubt, as is hinted, if Mr. Edison associates himself with this battery, we shall hear a great deal more about it, and its capabilities under the most favourable conditions. The last I heard was that the size of the battery cells, which were of cast iron, had increased to a capacity of about 15 to 16 gallons, and an electric capacity of something like 6,000 ampère-hours; the E.M.F., with an output of 100 to 150 ampères, being about ·7 volt. To avoid the necessity of employing a large number of cells when lighting direct from the battery, an expedient was found in using a combination of six primaries in series (which were said to have less than $\frac{1}{500}$th ohm resistance), charging a number of accumulators in parallel, which again were connected in series on the lighting circuit; the whole being operated by a series parallel switch, such as was employed by Planté in his researches. I should like to know what is being done with this interesting battery, and how far the anticipations of its original promoters have been realised. Mr. Edison evidently sees something in it, and, like many other ideas whispered over the waters, we shall see our "cousins" availing themselves of all its advantages, or "returning after many days."

It will probably not be uninteresting to quote the plan for dealing with the products. The battery exhausted, we have in solution zincate of potash (soda was not so good because it carbonated more readily, and the E.M.F. was less), and the oxide of copper is reduced to the metallic condition. To revive the solution there were, as far as I can remember, three plans. The first was to throw the zinc down with sulphide of sodium, which adds its own base to the alkali, and thus increases it; the second was to add sulphide of barium; and the third, from which great results were expected, was to throw down the zinc by means of sulphuretted hydrogen; the sulphide of zinc thus formed being afterwards employed with an acid for the further generation of sulphuretted hydrogen for the treatment of subsequent quantities of the zincate of potash. "The same quantity of sulphuretted hydrogen serving indefinitely for the operation of regeneration." When hydrochloric acid was employed, and the zinc was in solution as a chloride from the sulphide, sulphide of barium was added, which reproduced the sulphide of zinc, after first throwing down any iron which might be present with bleaching powder; and it was from the sale of this sulphide that a good return was expected. When sulphuric acid was employed both the barium and zinc went down, the former as the insoluble sulphate, both then forming the pigment, or "sulphide of zinc white," in commerce, the barium compound being the adulterant. Then there was a plan for getting back the zinc by electrolysis, mercury being the cathode—the zinc separated by distillation of the mercury. The copper was oxidised in a furnace. After all this, I am not sure that the company ever paid a dividend, a very good criterion of its working. But perhaps Mr. Edison will add some dividend-paying element; his name is a power; and after all these thousands of experiments of his! There is another gentleman who could tell us something about this battery, Mr. Hugh A. Fergusson; he has been connected with its operations for a long time, and, I believe, introduced it to the Americans some years ago.

James C. Richardson.

Ozone.

I much regret not feeling justified to gratify your correspondent's curiosity in naming the hundreds of commercial uses of ozone, or, as I would have called it, electrical gas. I decline, for more reasons than one, to specify the commercial uses of ozone from A to Z; but as I have offered an invitation to view my ozone works, your correspondent will, I am sure, have every opportunity of seeing it. I herewith forward a few samples of the uses made of ozone, with a list of other uses to which I have from time to time applied this remarkable and powerful gas. I am engaged at the present in compressing the gas for portability, and have been fairly successful, with the exception of the valves required for this speciality gas. I hope, however, to devise a means of overcoming the difficulty, when I shall be able to forward per rail ozone to any part where it is impossible to erect a producer plant.

An erroneous impression exists that to produce this electrical gas sea air is required; that is not so, although my experiments and analysis of various atmospheres on sea and land point undoubtedly to the former for superiority. I am sanguine of success in erecting a plant on any ordinary floating sea vessel capable of producing a high quantity of ozone which might be utilised for medical or sanitary purposes only. The dynamo machines could be utilised in lighting the ship, as I have proved at my ozone works.

Now, I wish to point out that I do not claim a monopoly in the uses of ozone or electrical gas, but what I claim is:—

1. Having practically solved the problem of producing ozone (or electrical gas) upon an unlimited scale for various commercial industries.
2. Having practically carried out a model plant for producing and applying ozone commercially.
3. That my process is the only process in the world which produces from the atmosphere ozone or electrical gas on a commercial scale.

I have the assurance to believe that the production of electrical machinery for producing this remarkable gas will form an entirely new era in electrical engineering.

Ernst Fahrig, T.E.

Munro and Jamieson's Pocket-Book.

In the first, third, and fifth editions of Munro and Jamieson's Electrical Pocket-Book, it is stated that "The number of cells required to form an accumulator is got by dividing the resistance of the lamp to be fed by 2."

Probably the word "resistance" is a misprint for "voltage:" for a lamp may have about 90 ohms resistance to give 16 C.P., or about 45 to give 32 C.P., or about 130 to give 10 C.P. These figures are taken at random from measurements of lamps described as of these several C.P. But all the lamps are marked as of 48 or 50 volts, and would therefore require some 25 cells in the secondary battery.

Perhaps, however, a high resistance lamp, say of 150 ohms, might be run as an 8 or 10 C.P. by 25 cells, or as twice that C.P. with about twice that number of cells.

Is there any method of determining the prescribed voltage of a given lamp (unmarked)?

The cold resistance of the lamp can be taken, and the length and area of its filament can be guessed at pretty nearly. Are those data sufficient to determine the voltage at which the lamp was intended by the maker to be used, or at which its life, and its efficiency for that life, would be a maximum?

Ajax.

SILVER [illegible]

[illegible]

MANUFACTURERS OF [illegible]

[illegible]

COTTON AND SILK [illegible]

L[illegible]